



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

H152.9



HARVARD UNIVERSITY

Mineralogical Laboratory,

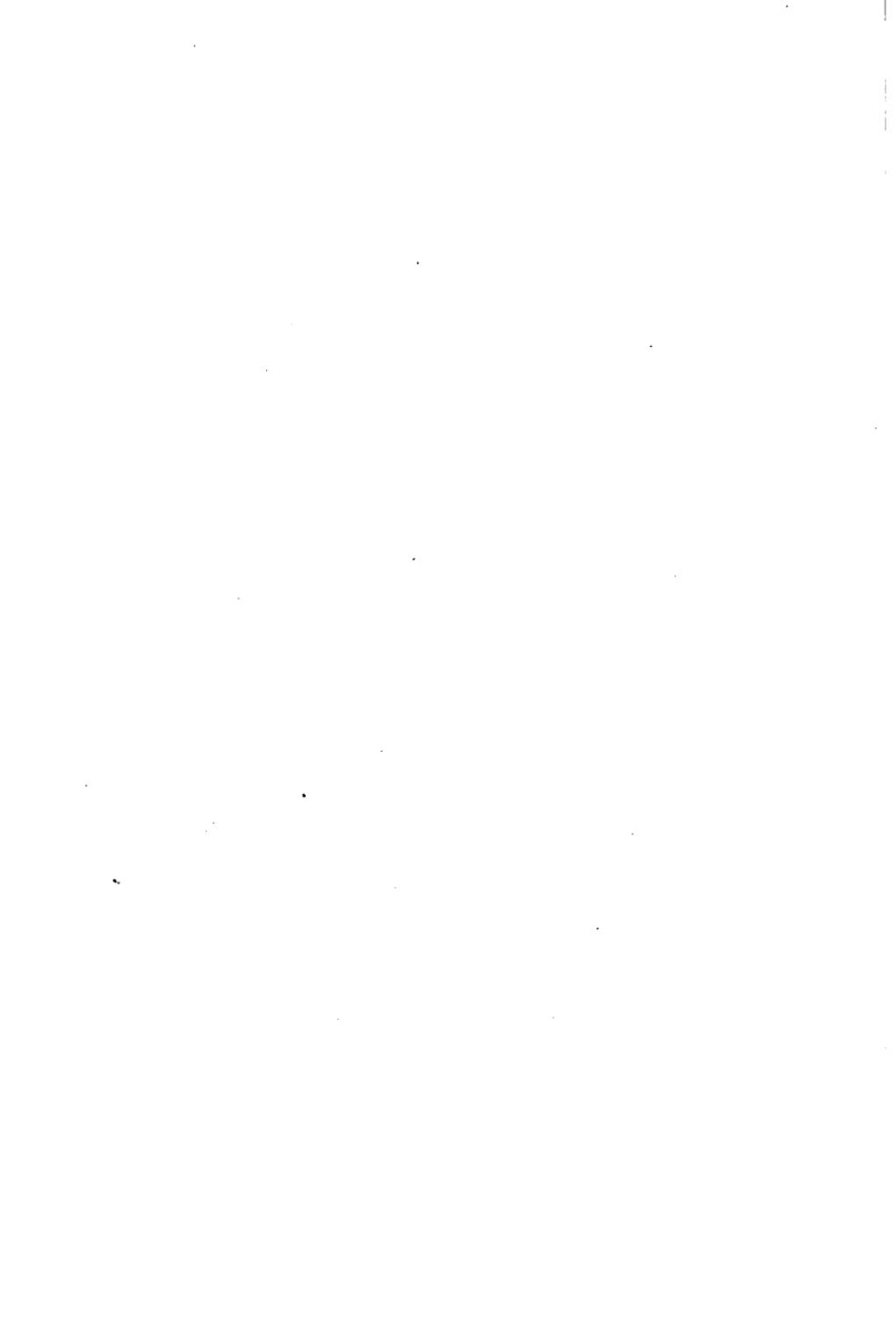
UNIVERSITY MUSEUM.

Transferred to
CA SCIENCE LIBRARY





E-432



MODERN PIGMENTS

TP
936
M22 VEHICLES

AND THEIR

THEIR PROPERTIES AND USES CON-
SIDERED MAINLY FROM THE
PRACTICAL SIDE

AND

HOW TO MAKE TINTS FROM THEM

BY

FREDERICK MAIRE

EX-EDITOR OF "PAINTING AND DECORATING," AUTHOR
OF THE "MODERN WOOD FINISHER," THE
"MODERN GRAINER"

FIRST EDITION

FIRST THOUSAND

NEW YORK

JOHN WILEY & SONS

LONDON: CHAPMAN & HALL, LIMITED

1908

H152.9

22. 1907.

Mineralogical Laboratory

COPYRIGHT, 1907,

BY

FREDERICK MAIRE

Stanhope Press

F. H. GILSON COMPANY
BOSTON, U. S. A.

PREFACE

It is to be regretted that notwithstanding it is a matter of prime importance that both dealers in painters' supplies and users of the same — the painters and decorators — should be well posted about the materials they handle, the vast majority have but the faintest ideas concerning the properties of pigments. One would naturally suppose that dealers ought to know all about them, their values, cost of production, qualities and defects. Without such knowledge they cannot truthfully answer the questions daily put to them. This ignorance has made it possible for unscrupulous manufacturers to palm off almost anything upon them. Every manufacturer and dealer has been a law unto himself, each differing from nearly everyone else in the trade. This lack of standards was really due to the indifference caused by the lack of knowledge on the part of both dealers and consumers. It has enabled the unprincipled to fleece an unsuspecting public out of millions of dollars.

Now that the public is being made fully aware of what they buy in the way of food, and that the general government and most of the states are working together in enforcing laws which require manufacturers to state upon labels placed upon packages an exact statement of what they contain, it is to be hoped that the same protection will be extended to all other compounded material in the paint line which is subject to adulteration.

The blame for adulteration does not rest upon the shoulders of the manufacturers and dealers only. Ignor-

rance of what constitutes the value of an article and a desire on the part of consumers to obtain it at a cost below what it is worth are also very strong factors—possibly the main ones why goods are adulterated at all. Manufacturers and dealers would not undertake to manufacture or sell material for which there would be no demand.

The Master Painters' Association has done some excellent work in past years to open the eyes of painters, and through its efforts in showing up the rottenness in the paint trade existing at the time of its inception a great change for the better has been brought about.

The trade journals, however, have done even more real good by bringing this work of the association to the knowledge of thousands of those painters who are not members of the association and who otherwise would never have heard of it. Thanks to this agitation which has been going on for the past eighteen years, the paint situation is in a much healthier condition to-day. Standards of quality are being established, and it is possible to obtain colors dry, ground in oil, Japan or water, which are exactly what the label represents them to be.

It is not within the scope of this little book to go into the detective business nor to make a specialty of exposing the tricks of trade. Its purpose is to give a brief and concise history of all valuable pigments useful in painting—the main sources of their derivation and supply; their properties and chief uses; their good qualities and their defects will be pointed out and incidentally there will be presented the best methods of detecting adulteration.

While tons of literature have been issued by the trade journals and in book form, very little has been written

upon pigments, and most of that has been in short sketches and merely as a side issue to the main subject matter of the volumes containing them.

Some excellent books on pigments have been published in England and Germany. These were written by chemists and are of use to manufacturers in particular. They mainly treat what may be called the scientific side, the practical being only treated incidentally or ignored entirely. Of this character are such admirable works as Field's Chromatography. Its high cost, even if it treated pigments more fully from the consumer's viewpoint, would prevent its purchase by the bulk of those who otherwise would be interested in it and no doubt procure it.

It is impossible in as small a volume as this to enter into the chemistry of pigments nor into some of the intricate details of manufacture and preparations for use, except in the briefest manner that will give the reader a fair idea of its composition. This is about all that painters or dealers require to know of the chemical side of pigments. Additional details would be of no importance, and none outside a manufacturer of colors would be interested in them. This manual is written for the men who use or sell pigments and who mainly want to know what they can expect of them.

The author has made use of the best that has been said upon the subject matter in the past. He has consulted some of the best authorities and had access to nearly everything that has been published on pigments, many of these books being now out of print. He was also very fortunate in that for a few years he had the pleasure of having intercourse almost daily with the late lamented Wm. C. Wilson of Philadelphia, who at that time was probably the best posted man on pigments in America. The information thus obtained has been largely drawn upon.

This little book will be of value to the young man who is starting out to learn the painter's trade. It will teach him what he ought to know about paints and what he will never learn from the average journeyman who is usually reticent and may very likely not know enough about pigments to answer a novice's queries. It will be useful to many painters who have never had an opportunity to study the matter of pigments, except in a haphazard sort of a way — without system and with much guess-work. As to the dealers, many of them are druggists who have a fair knowledge of chemistry. These will find the chemical details sufficient to give the information that is wanted. Other dealers not so well informed find also enough explanation to enable them to know if they are buying the right goods or paying a fair price.

It is probable that errors have crept in and will crop out when this book comes out in print. Good care has been taken that there be no glaring ones, but it is still possible that some may inadvertently have been overlooked. Be that as it may, infallibility is not claimed, but the author has given out what he honestly thinks is reliable. Such as it is, this little book is confidently submitted to an indulgent public.

F. MAIRE.

HAMILTON, ILLINOIS.

Aug. 30, 1907.

CONTENTS

CHAPTER I

	PAGE
PREFACE	iii
PRELIMINARIES	1

Definition of the word "pigment." — Some substances are real pigments in water, but only so by courtesy in oil. — Synopsis of the manner in which the subject matter is to be treated in succeeding chapters.

CHAPTER II

WHITE PIGMENTS	8
--------------------------	---

Introduction. — White lead, history, chemistry, and manufacture. — Dutch process; stack method of corrosion, cylinder method, sulphate of lead, sublimed lead. — Dahl process; properties and uses. — Blow pipe and other tests for impurities.

CHAPTER III

WHITE PIGMENTS (<i>Continued</i>)	32
---	----

Zinc white; its history and chemistry, its properties and uses.

CHAPTER IV

WHITE PIGMENTS (<i>Continued</i>)	40
---	----

Earth whites; their general characteristics. — Whiting (carbonate of lime); properties and uses. — China clay (kaolin); properties and uses. — Gypsum (sulphate of lime); properties and uses. — Silicate earths; properties and uses. — Silver white; properties and uses. — Baryta white (sulphate of barium); properties and uses.

CONTENTS

CHAPTER V

	PAGE
YELLOW PIGMENTS	57

Ochers; history and early use made of them, methods of mining and preparing for market, divided into two classes, the silicious and aluminous, various characteristics, properties and uses of each. — Grinding colors in shops, no economy therein. — American ochers; their properties and uses. — Artificially made ochers.

CHAPTER VI

YELLOW PIGMENTS (<i>Continued</i>)	73
---	----

The chrome yellows; their various tones. — Medium chrome yellow, only the chromate of lead. — Canary and lemon chrome yellows. — Baryta lemon chrome yellow; characteristics, properties and uses. — Adulterations; how to detect them. — Comparisons and the judging of values by the scale test. — Full directions for making it. — Useful for many other colors.

CHAPTER VII

YELLOW PIGMENTS (<i>Continued</i>)	86
---	----

Gamboge; production, properties and uses. — Aureolin or cobalt yellow; properties and uses. — Indian yellow; properties and uses. — Naples yellow; production, properties and uses. — Dutch pink, yellow lake, Italian pink, quercitron, etc.; properties and uses. — Cadmium yellow; properties and uses. — King's yellow or orpiment; properties and uses.

CHAPTER VIII

RED PIGMENTS	95
-------------------------------	----

Vermilion. — Quick silver vermillion; its history, chemistry and manufacture; properties and uses, adulteration. — The imitation or vermillion reds; peculiarities, properties and uses. — American vermillion; properties and uses.

CHAPTER IX

RED PIGMENTS (<i>Continued</i>)	106
--	-----

Venetian red; history and manufacture, characteristics, properties and uses. — Indian reds; characteristics, properties and uses. — Tuscan reds; properties and uses. — Red oxide of iron; characteristics, properties and uses.

CONTENTS

ix

CHAPTER X

	PAGE
RED PIGMENTS (Continued.)	116

Red lead; its chemistry and manufacture, properties and uses. — Lakes; what they are. — Alizarin and purpurin; their uses in the manufacture of lakes. — Rose pink; properties and uses. — Rose lake; properties and uses. — Madder lakes; include all shades and varieties of red lakes made from alizarin and purpurin, many sold under proprietary names. — Indian lake; properties and uses. — Carmine and the cochineal lakes; characteristics, properties and uses. — Red ochers; what they are.

CHAPTER XI

GREEN PIGMENTS	129
---------------------------------	------------

Chrome greens; composition, properties and uses. — All greens under proprietary names are chrome greens. — Green oxide of chromium, true chrome green; properties and uses. — Cobalt green or zinc green; preparation, properties and uses. — Viridian; properties and uses.

CHAPTER XII

GREEN PIGMENTS (Continued)	139
---	------------

Terre verte; properties and uses. — Verdigris; derivation, properties and uses. — Paris or emerald green; chemistry, properties and uses. — Malachite; properties and uses. — Scheele's green; properties and uses.

CHAPTER XIII

BLUE PIGMENTS	145
--------------------------------	------------

Ultramarine blue; history, character, properties and uses. — Prussian blue; chemical constituents, preparation, properties and uses. — Chinese (Prussian) soluble blue; properties and uses.

CHAPTER XIV

BLUE PIGMENTS (Continued)	152
--	------------

Cobalt blue; preparation, properties and uses. The artificially prepared cobalt blue. — Ceruleum; properties and uses. — Chessylite; properties and uses. — Smalt; properties and uses.

CHAPTER XV

BROWN PIGMENTS	PAGE 156
--------------------------	-------------

Umbers. — Raw umber; characteristics, properties and uses. — Burnt umber; properties and uses. — Siennas. — Raw sienna; where obtained, preparation, properties and uses. — Burnt sienna; properties and uses. — Vandyke brown; properties and uses. — The metallic browns; provenance, properties and uses. — Spanish brown; properties and uses.

CHAPTER XVI

BLACK PIGMENTS	170
--------------------------	-----

Lamp black; characteristics, manufacture, properties and uses. — Carbon or gas black; properties and uses. — Ivory black. — Coach black. — Drop black. — One and the same; preparation, properties and uses. — Charcoal black or blue black; properties and uses. — Graphite or plumbago; properties and uses.

CHAPTER XVII

SYNONYMS	181
--------------------	-----

A table to facilitate the finding of pigments known under various names.

CHAPTER XVIII

VEHICLES USED IN GRINDING PIGMENTS AND IN APPLYING THEM	189
---	-----

What vehicles are. — Raw linseed oil. — What a drying oil is. — What a fixed oil is. — The only ones of use for exposed painting. — The provenance of linseed oil; its manufacture and preparation for use. — How linseed oil dries; its properties. — Boiled linseed oil; its properties. — Nitric acid and other tests for impurities. — Poppyseed oil; characteristics, properties and uses.

CHAPTER XIX

VEHICLES (<i>Continued</i>)	206
---	-----

The volatile oils; what they are; their properties and uses in paint vehicles. — Spirits of turpentine; how obtained; its diuretic properties. — Naphtha and benzine; properties and uses. — All volatile oils solvent of gum-resins used as such in varnish making.

CONTENTS

xi

CHAPTER XX

	PAGE
VEHICLES (<i>Continued</i>)	211

Varnishes, japans and alcoholic shellac solutions. — Varnishes; what they are; their properties and uses as binders and vehicles. — Japans; some confusion as to what they are; their use as vehicles, driers, alcoholic shellac solutions; properties and uses.

CHAPTER XXI

SUBSTANCES USED AS CORRECTIVES AND BINDERS	217
--	-----

Waxes. — Beeswax used in encaustic painting in earliest civilization. — The vegetable waxes. — The paraffin waxes.

CHAPTER XXII

SUBSTANCES USED TO BIND PIGMENTS IN CONNECTION WITH VEHICLES	220
---	-----

Glues; manufacture, properties and uses. — Gum arabic; provenance, properties and uses. — Starch, dextrin, honey, sugar, molasses and glycerine. — Their properties and uses.

CHAPTER XXIII

DRIERS AND SICCATIVES	229
---------------------------------	-----

Boiled linseed oil as a siccative; properties and uses. — The lead oxides; the oxides of manganese. — Acetate of lead. — Sulphate of zinc. — Their action upon linseed oil and other fixed oils considered.

CHAPTER XXIV

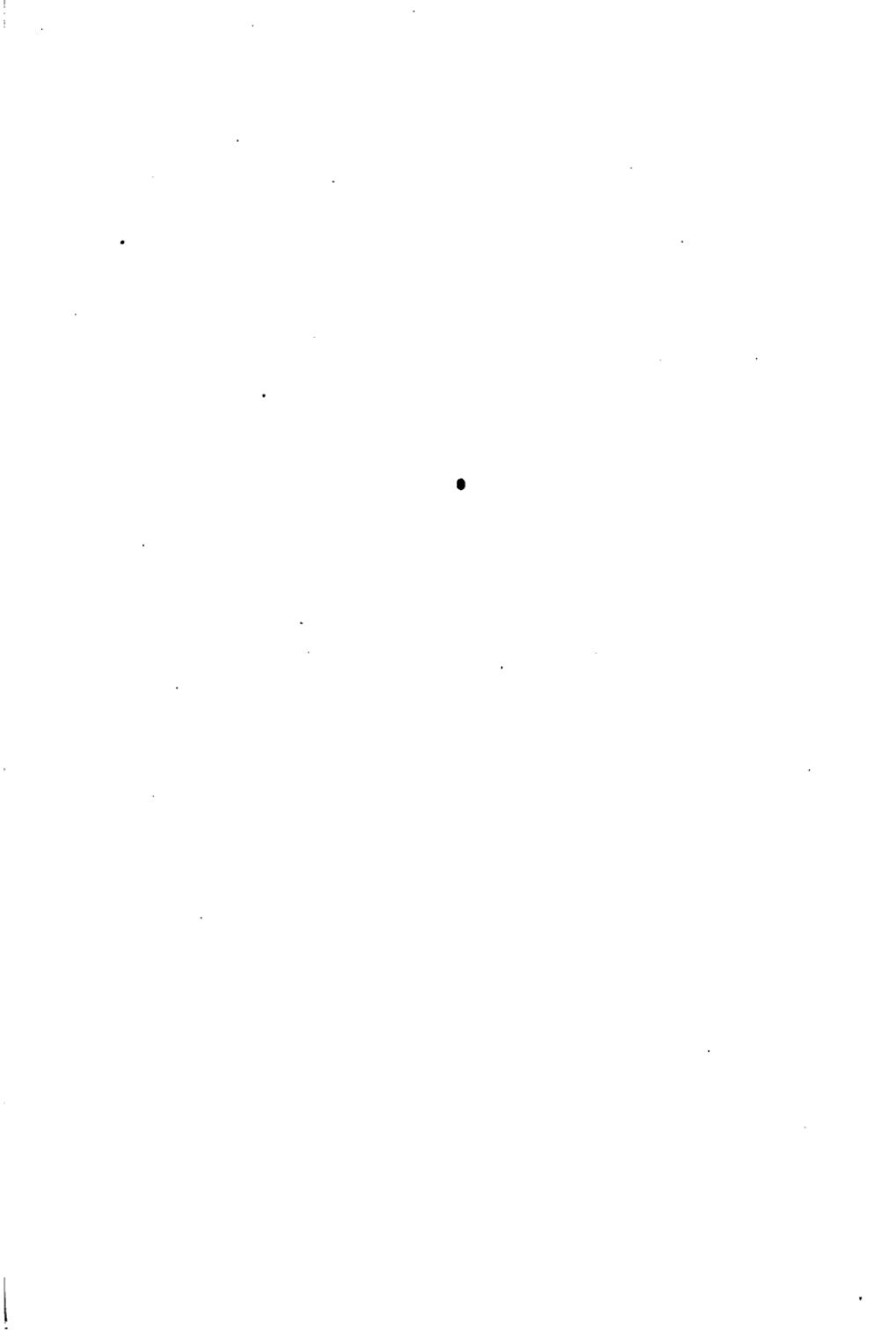
THE COMPOUNDING OF PIGMENTS	235
---------------------------------------	-----

Philosophy of color. — Rules to guide one in the compounding of tints.

CHAPTER XXV

A LIST OF THE PRINCIPAL TINTS AND OF PIGMENTS REQUIRED TO MAKE THEM	243
--	-----

A few cautionary words followed by the list of tints.



MODERN PIGMENTS AND THEIR VEHICLES: THEIR PROPERTIES AND USES

CHAPTER I

PRELIMINARIES

IN subsequent chapters it is intended to take up a study of the various pigments which are used in ordinary painting, as well as those employed by decorators for either distemper or oil painting; those used by coach and car painters will also be reviewed. The whole field will be covered, with possibly the exception of a few pigments which have become obsolete, and which have been replaced by better ones.

The vehicles which are used in the application of pigments will also be noticed, as in some respects they are really of more importance than the pigments themselves. Binding substances and correctives will also be described, and their character and uses noted.

The word "pigment" is applied to coloring substances which, when mixed with suitable vehicles, form paints. It means "color," the word "color" being used indifferently to mean a compound of various pigments, or a pigment which has been ground ready for use; the various pigments put up in cans and found for sale at the supply stores are commonly known by that name. No matter

what medium has been used in the grinding of pigments, be it linseed oil, japan, varnish, or water, all are known as "colors" either simple or compounded. The word "pigment" is therefore much more restricted than that of "color."

Strange as it may appear, this word has not yet received its final definition. It is vaguely applied to designate any substance that may be used in the preparation of paint, fillers used in wood finishing, etc. It is given to any solid substance used in compounds, and is replacing that word in paint parlance at least.

Strictly speaking, the name of pigment should never be given to any substance unless it has the inherent power of its own to impart color to other substances with which it may be mixed. Originally it was used in this strict sense only, and it should be so restricted. As it is now, the adjunct substances possessing no coloring matter of their own which are usually added to true pigments with no other purpose in view than that of adding weight without changing the original color of the pigments in combination, are all called pigments too. It is a misnomer. Possessing no coloring matter, the makeweights are certainly not entitled to the name.

Correctives — sometimes useful adjuncts to a pigment — are frequently of the same colorless character as the makeweights, and therefore not entitled to be classed with them. To illustrate exactly what is meant, the following example is given: Starch and glue are solid substances, but after they have been converted into thin paste by the addition of hot water they are colorless, and when they have been mixed with whiting or zinc or any "colors," a distemper color has been prepared of which either may form a component part, though not as a pig-

ment; the addition does not change the color of the compound in the least.

Here is another example: Liquid fillers, and fillers for the light hard woods, contain some transparent solid substance, such as very finely ground silex, quartz, etc.; the manufacturer in his pamphlets calls it the pigment part of the filler. He uses it in this connection actually in place of the word "solid." This is wrong, and befogs the real meaning of the word, which originally seemed admirably adapted to express the thought of coloring matter.

By courtesy some few substances will be designated as pigments that do not possess any coloring matter of their own to impart to other materials with which they are mixed. For instance, barytes has no coloring matter to impart to other pigments ground with it in oil or japan, but when used alone in water it has a white color. Several such substances which do not deserve to be classed as colors when mixed in oil, have coloring when mixed with water; and to save a double definition of them, the term "pigment," which is applicable to them when in water but which would not apply when mixed in oil, is nevertheless retained in this instance, but to which they are really no more entitled than is starch or glue. For similar reasons, carbonate of lime (whiting), sulphate of lime (gypsum), finely powdered silicate stone or earths (silver white or English kalsomine), will also be included in the list of pigments, for they are properly so called when in water (if not in oil).

To facilitate the search of any particular pigment, so that they can be readily found without even taking the trouble to look them up in the index, these have been placed in groups of the principal colors, and all pigments of that tone or order will be found under the proper heading in the class to which they belong. The principal

pigment, or that which is mostly used, will be placed at the head of the list, and others will follow in the order of their usefulness.

Under each will be given, as far as practicable, a brief historical sketch of its origin and derivation, its manufacture and preparation for market, its properties and uses, the best and easiest methods of detection if subject to adulteration, the enumeration of other substances which are injurious and with which it should never be combined, and, lastly, any other points of especial interest.

It was stated in the preface that it was not within the scope of this book to treat the subject matter "pigments" from the standpoint of the chemist or color-maker, and reasons were given why; but the chemistry of most all the pigment will at least be briefly noticed — simply the giving of their component parts, or, where they have a recognized formula, the giving of that. In a few of the better known ones, a full enumeration of their constituent elements will be given, as this is frequently an index as to their character; but when the desirability for this occurs, it will be done in a way that can be understood by those not familiar with chemistry, and in words as free of technical expressions as possible. A person needs not to be a chemist nor familiar with that science to understand a great deal of what constitutes the chemistry of paint; good common sense will go a long way with the reader to enable him to recognize the true from the false.

The researches and experiments made in the field of color by eminent scientists within the last century — many by men of the greatest ability, and who were guided more by a love of attaining knowledge than with the monetary inducements — have made the task of writing up "pigments" a comparatively easy one. The author cannot claim a great amount of originality, nor has he

made any great discovery himself, so that what he has to say is none of his finding out, nor is it the first time that it has appeared in print. The present treatise is, in the main, one of compilation and arrangement. Nearly half a century of practical handling of pigments, and experimenting with them in paint factories and in the ordinary practice of the paint shop, have helped him form some decided opinions about the application and mixing of most pigments, and upon this fund of knowledge the writer has drawn freely and without stint, and it is embodied in this treatise with that of others.

A good knowledge of the properties of pigments is imperatively demanded of any one who wishes to be up in the paint business, either as a dealer or user. There is much to be learned about the proper mixing of pigments and about vehicles suitable for the various purposes: the future has a fine field for research in that direction, for we do not know it all by long odds, and there remains much to be revealed at some time or another. Much of what is known now is not of such a character that one can absolutely rely upon it; hence so many opinions which are diametrically opposed to each other about the preparation or application of the simplest of mixtures. Humiliating as it may be to one who has made a lifetime study of the paint business, the truth requires and compels one to acknowledge as much as appears above, for what now passes as orthodox in many good paint shops, will be classed as rank heresy in others of equally good repute. Therefore it is only by a thorough and intimate knowledge of pigments, vehicles, and conditions that any one can hope to grope to half-way certainty in sundry instances, and to a fuller one in a very few others. If it is so hard to get at the truth for those who are constantly studying, what must the practice be

of those who do not study? Assuredly they can have nothing but routine and guesswork.

There is much to be learned,—all are agreed upon that. Chemists in the employ of paint manufacturers, and others who are inclined to researches in the same direction, usually make these their life hobbies; but as it is commonly on the side from their regular work, they are somewhat hampered; but every once in a while one hits upon some process or other which is beneficial and helpful in the manner of fixing the coloring matter contained in certain pigments more permanently than was ever done before, or indeed it may be the discovery of entirely new ones. Much has been done, but much still remains to be done by the chemists. On the practical side, however, there is still a great deal to be learned; and here is work for the thinking painters, and also for the associations of master painters, who can do a great deal of good by bringing together those who, while they differ in opinions, can compare results, and thus aid in getting at true solutions of vexatious questions.

Many important discoveries of the chemists were prompted by suggestions made to them by the tests of practical men. Theoretical chemists and practical men generally cannot afford to work aloof from each other. Either one without the help of the other is more or less of a failure. Theory must be proved by practical tests to be right. Many chemists are too apt to belittle the value of suggestions made by well-posted painters, and to regard them too much in the light of useful machines for the proper application of paint. There can be little wonder that many of their compounds and discoveries of new preparations prove of no practical value. The Patent Office at Washington, D.C., is a cemetery where thousands of inventions in the paint line lie buried,

unknown and undisturbed, simply because of their impracticability.

On the other hand, the painter too often looks at the researches of scientific men with a sneer and turns up his nose at them. All would find it advantageous to study the writings, and make use of the information they would find in them, of such men as Chevreuil, G. Field, L. E. Andes, J. Lefort, A. H. Church, and many others. Unfortunately, some of these men's works are now out of print, and are to be found only in a few of the larger public libraries.

The German language is richer with valuable scientific works on pigments than is the English, but these are very expensive, and mainly of interest to men well up in chemistry. It is hoped that translations of some of their best works may be made, adapted to the popular understanding.

CHAPTER II

WHITE PIGMENTS

As it was stated in the preceding chapter, to facilitate the search for any one given pigment, all have been classed into groups of certain colors, and within each will be found all which belong to it by being nearer in tone than to any other group. It is fitting to commence with the *whites*, as this group is the most important of all. The whites are not only important to the painter on account of its "*self*" color and the one self color mostly used in painting, and rightly so on account of cleanly tone and brightening effect, but also because the whites form the *base* upon which nearly all tints are made by the addition of colored pigments.

The ideal white pigment, is probably present to the average painter's mind, but the realization of it, as yet, has been far from the ideal one. Every practical user of paint who has given much thought to it, has some such ideal pigment mapped out in his head. He has ideas of what it should be like,— all good qualities, with none bad,— but when he goes out among the realities of life and looks, he does not find it. His ideal white pigment is to be found only in his mind. A feeble portion of the good qualities desired in a white are to be found unassociated with some very bad ones in any one white pigment. In actual practice it turns out that for every good quality shown, there will be found a counterbalancing defect which will prove a thorn in the flesh.

The above is written for the purpose of preparing the reader for the defects which are found in all the most prominent white pigments, and also to guard him against over-confidence or extravagant expectations from the use of any.

WHITE LEAD

History

White lead is the most prominent and best known of any of the white pigments on the list. There are few persons to be found, even outside of those connected with the paint trade, but who are not more or less familiar with or at least have heard of it in some way. Mankind has known white lead a long time. It is of very ancient antecedents. That the oldest civilizations knew it, is evidenced by the remains of their pottery — the glazing upon it being obtainable only by the use of white lead. Such Latin writers as Pliny and Vitruvius give the process of its manufacture from lead and vinegar. It was then known under various names, some of which have come down to our own times, and which are used to designate it to-day. For instance, "Cerusa, minium album" in Continental Europe is still known as ceruse and white minium. Recent excavations have brought to light a number of well-preserved specimens of white lead which show that it must have been an article of common use in ancient Greece and Egypt.

The above details are given because many people suppose white lead to be a comparatively new discovery, or at best dating back but a few centuries. It is true, however, that only a little over two hundred years have elapsed since white lead commenced to be manufactured on a large scale by what is known as the

“Dutch Process.” Really, the principles of that system are the same as those described by Pliny, the only difference being that a different application of the same is made use of in the Dutch process.

While Holland has the honor of having given its name to the process that is usually employed in the manufacture of white lead to-day, that is, no doubt, due to the fact that it was in that country that were made the first efforts to manufacture it on a large scale in Europe. It had no monopoly of it, for it was not long before manufactories of it were to be found scattered in many European countries. Factories were started in Germany, France, and England not very far behind. Some of these brands of white lead soon attained a high degree of excellence, and have come down to our own times, their names being still used to designate some very fine qualities,—such as Cremnitz white, for instance, which was manufactured in the city of Crems in Germany. Not within the past hundred years has there been any white lead manufactured there, but the name still exists, the lead usually sold under that name being a flake white. So much, then, for good quality; for tradition still preserves it, and persists in handing a name down to us more than a century after the original had ceased to be made.

The Dutch Process

The “Dutch process” of corrosion has been handed down to us with but few changes from what it was in its primitive days. These changes consist only in more sensible labor-saving devices for handling the various materials used in the manufacture of white lead.

Before going into the description of the manufacture of white lead by the “Dutch process,” it will be best under-

stood if its composition be well studied; therefore the chemistry of white lead will now be given.

The component parts of white lead vary somewhat in the several specimens of it. It is sometimes erroneously called a carbonate of lead, but that it is not; at least, it is not a pure one. If it was, it would be of little value as a pigment, or rather its value would be greatly lessened. Really, it is a combination of lead carbonate and lead hydrate; the latter is what gives the saponifying and binding properties. This hydrate of lead should be present in the proportion of 30 to 35 per cent, and the carbonate should enter the combination in the proportion of 65 to 70 per cent. Lead hydrate has the property of counteracting the chalking tendency of the carbonate, but it has the drawback of rendering white lead less opaque or more transparent. White lead should therefore in round numbers have two thirds of its weight of carbonate of lead and one third of it the hydrate. Its formula is 2PbCO_3 .

The usual process employed in the manufacture of white lead is what is known as the *stack* system of the so-called Dutch process, which name in reality simply stands for the chemical process producing the corrosion of the lead metal by the agency of dilute acetic acid fumes, carbonic acid, hydrogen, oxygen, and heat. The exact manner of conversion of the metal into a carbonate is very imperfectly understood even at this late day by chemists, who in their conclusions merely guess at it with more or less plausibility in their theories. It would seem that first of all it is converted into an acetate of lead, but as it has more affinity for carbonic acid than it has for the acetic, that it is transformed into that. As to the "how" and "when," this is now clouded in mystery, and it still remains for some one to satisfactorily explain.

Manufacture

The metallic lead used in the manufacture of white lead should be soft and free from antimony, silver, or any other impurity. If any of them are present in an appreciable quantity the corroded lead will not be so white and will also be specky. There are large refining plants in the United States. The largest in the world is located in Newark, N.J., where metallic lead is desilvered at low cost, the silver obtained usually paying the cost of processing it. This desilvered metal makes the whitest lead. Spanish lead used to be employed by some of the eastern corroders, but what with the duties, its scarcity and increased cost, it is now but little used. Some is employed in making the finer qualities of flake white; it makes a dense, and therefore more opaque, white lead.

The pig lead — the large and heavy bars of metallic lead as they come from the smelters — is melted into what in corroder's parlance are called *buckles*. These buckles are thin, perforated, circular plates of lead, and are about one-sixteenth of an inch thick. The disk-like buckles are placed in porous clay jars. These jars have projecting knobs on the inside upon which the buckles rest. These projections serve the purpose of separating the buckles from each other in the jar. This allows a circulation of air, heat and of the gaseous attacks of acetic acid vapor reaching every part of the buckles, as it can ascend from one to the other through the perforations. There is also a large space left empty at the bottom of the jar into which is poured dilute acetic acid of the strength of vinegar. As vinegar owes what value it has as a corroding agent to the acetic acid it contains, one can readily see that the claim made by some corroders that they use actual

vinegar instead of dilute acetic acid, and making for this a point of superiority, is all "bosh." It is very doubtful if any corroder actually uses the vinegar of commerce, notwithstanding the claims made.

After the jars have been filled with buckles to nearly the tops, they are put into the "stack." To be more accurate, the jars are placed upon the floor of the stack in rows, and are filled from a large box containing buckles of lead which come from the melting room and shaping machine, and placed there in these boxes, which are carried to the corroding stack houses on an overhead railway which takes them wherever wanted, and from which they can be raised and lowered at will. After all the jars in the tier have been filled, the dilute acetic acid is fed to each jar from a hose in short order.

The stacks themselves are compartments inside the corroding houses. They are boarded up, and extend from the ground floor to the upper one, which is the working floor. The diagram will give an idea of the arrangement. The corroding buildings may be of any length with any number or size of stacks inside of them. Many of the big corroding plants have a number of corroding houses. Some of the stacks inside of the same building may be idle or in many of the different stages of corrosion, each stack being independent of the one next to it. Thus one can see in the same corroding house, one or more stacks being filled up with buckles and jars, others engaged in the corrosion process, while others again are being emptied and cleaned out. It was stated that the corroding agent was dilute acetic acid of the strength of vinegar, but that without heat would produce an acetate of lead only. So heat must be generated and carbonic acid must be developed. To produce both of these, the corroder uses spent tan bark, stable manure, or a com-

bination of both. Most people have seen how the market gardeners generate heat in their hot-beds in the coldest weather by using stable manure; the process is the same that the corroder employs. A layer of this material is first placed upon the ground floor of the stack, and leveled up, and a layer of jars placed upon it. Upon the jars a layer of boards is placed to keep out the next layer of manure which is placed upon the boards, then another of jars, then of boards, then of manure again, and this is repeated over and over until the stack has been filled nearly to the level of the working alley above.

Each one of the layers in the stack has a chimney of its own. This chimney consists of four boards nailed together, and reaches to the top of the stack and acts as an indicator to what is going on at each tier. The chimneys are kept open or shut according to requirements.

The heat generated by the tan bark and manure vaporizes the acetic acid in the jars, and then the process of corrosion goes on until all the acid has been evaporated and all the heat has been spent. It usually takes from 75 to 90 days to accomplish this, and when it has exhausted itself the layers are ready to take down. During the generation of heat, carbonic acid is produced, and it is from this source that it is supplied to the lead.

The pots when taken down are emptied into large revolving cylinders which separate the white lead from any that remains uncorroded. The white lead is afterwards washed through several waters to free it from any acetate of lead or from free acetic acid that may be present with it. Acetate of lead is entirely soluble in water, and can thus be readily gotten rid of.

The lead is then ground in water to free it still further from any acetate remaining, and finally filtered through a fine silk cloth which catches any specks of tan or

manure that may have found their way into the pots and that the numerous washings of the lead have not removed.

The white lead is now run into large vats, where it is allowed to settle. The "pulp," as the mass of settled lead is called, is taken to the drying pans, which are in a separate chamber built for that purpose. This chamber is fitted with steam pipes all around it, so that a very hot atmosphere can be maintained until the lead in the pans — as the large, low vats are called into which the pulp is placed — is bone dry.

The lead is then crushed, and it is ready to sell, either as dry lead for grinding with oil as white lead, or for pottery use and the making of queensware and some varieties of chinaware. Lead ground in oil is the only form in which the painters usually see it.

To grind white lead in oil, the dry lead is first mixed with the quantity of linseed oil necessary to grind it, say about nine pounds and a half of oil to the hundred-weight of dry lead. It is first triturated in revolving mixers, from which it is carried mechanically to the grinding mills proper, where it is ground either double or single. The double mills pass the lead from the first to the second without manual labor.

The speed at which the mills are made to revolve during the grinding, and the lesser or greater amount of heat developed consequently by that speed, make the ground lead paste either tough and stringy in texture, or else short and soft. The white lead itself has nothing to do with it, as many erroneously suppose. From the same batch of dry lead, the grinder can turn out either kind or any intermediary degree between the two extremes simply by adjusting the speed of his mills.

White lead after grinding undergoes some mechanical change in its atoms, but the change is not a chemical

one. It should be perfectly cooled before it is packaged. Many manufacturers put it in large, tank-like kettles, which are surrounded with water. This makes the lead more unctuous, and gives it better working qualities. Lead so cooled will not harden in the packages, which sometimes happens when it is run directly from the grinding mills into them.

It was stated in the previous paragraph that lead acquires smoothness and better working qualities when it has been properly ripened in large masses before packing. Few manufacturers give it time enough for the process to become completed; all are in a hurry to turn over the product into money, and four to six months' extra waiting is hard on them after all the time which has been required since the pig lead was melted.

There is another system of grinding white lead, which is known as the "Pulp Process." The manufacturers call it, *pulp ground*, but in reality the lead is not ground at all—that is, it receives no other grinding than that which it received when it was ground with water previous to its becoming *pulp*. In that condition it is certainly finer than it is possible—or rather practicable—to grind the crushed bone-dry lead in linseed oil by many repeated grindings in the mills.

The wet "pulped" lead is run through presses by some; but nearly all manufacturers who make a "pulp ground" lead, withdraw the pulp as soon as it has settled down from the water, and take it direct to a "chaser."

A chaser is a circular, low-sided vat, in which revolves a heavy roller. This roller crushes and mixes liquids and solids together into an homogeneous mass. Chasers are used in preparing putty, etc.

White lead has a great affinity for linseed oil; for water it has none at all. The pulped lead having been placed

in the chaser, linseed oil is poured on it and the machinery is set to work; the lead, having more affinity for the oil, absorbs it, and the water is squeezed out by the weighty roller, a way of escape being provided for it, and in a short time it becomes displaced by the linseed oil which has been absorbed in its stead.

There is no question about the fineness of pulp lead if it has been properly ground before pulping it, nor can there be any about its whiteness. Many have considerable doubts about the possibility of extracting all the water out of the lead. Some well-posted men claim that three to five per cent of it remain; others again put these figures still higher.

Practical painters who have used pulp-ground lead for years say that it has acted no better nor no worse than other leads ground in the usual way. All, however, are not a unit in this testimony, and some claim that it chalks more readily. A person will be on the safe side if slow in adopting its use exclusively, but should proceed slowly in coming to a conclusion. By using it side by side with the old kinds, and noting its action, in time he may decide for or against its adoption. All things being equal, pulped lead has some good points in its favor, but time only, and lots of it, will decide its universal adoption.

There seem to be very little and surely no material differences in the methods of corroding lead used by the lead manufacturers, excepting possibly that some few have more mechanical labor-saving devices than the rest. Few improvements have been made other than those mentioned, and those mainly since the introduction of steam and other motive powers which have replaced animal and human energy wherever it was found practicable.

To sum up the Dutch process of corroding white lead in as few words as possible, it amounts to this: *It is the corrosion of metallic lead by aid of acetic acid, carbonic acid, oxygen, and hydrogen.*

When it was said in preceding paragraphs that there have been no improvements to speak of in the manufacture of lead by the Dutch process, this was meant in so far as the original application of the principle and of the system carried on by the Dutch and other European corroders of the long ago,—the stack method.

There is a new way of applying the same principles and agents of corrosion used in the Dutch process. Manufacturers who corrode lead in the new way, claim that they produce a white lead which has absolutely the same chemical composition as that produced by the stack system, that its atomic formation is the same, that its working qualities are the same and in some respects better,—in short, that it is the same.

It is not intended to pass an opinion upon the claims made by these gentlemen, nor to certify to their verity. What is here said must not be construed into an unqualified indorsement of them. They have some strong cards in their hands, and they seem to understand how to play them. That their system of corrosion saves much time and many manipulations, cannot be gainsaid; that it appeals to the intellect as being more progressive than the other, is also true. It gives the manufacturers a more perfect control of the action of the corroding agents in the process of corrosion, thus placing them in a position to make more uniform products.

Several manufacturers representing millions of capital have been corroding by the *cylinder system* for the past twenty-five years; others are adopting it in America and European countries. In the United States some two or

three factories using that system have a very large output. The practical men, the painters who use it, are seemingly well satisfied, so it looks very much as if the system had passed out of the experimental stage and that it was going to remain with us.

This cylinder method is very simple and easily understood. To all intents and purposes other than the manner of making the white lead it is entitled to have its product called "Dutch process" white lead as well as that produced by the stack system — if the proposition laid down in a former paragraph be the correct one. It is repeated below in a shorter form: That the name "Dutch process" stands for lead corroded by the agency of *acetic and carbonic acids, oxygen and hydrogen*.

The operations for the corroding of lead by the cylinder system are few. In the first place, the pig lead is melted and poured in a stream against which a jet of steam is made to play. This pulverizes the lead into fine, sandlike particles. This lead sand is placed in revolving cylinders connected with generators wherein acetic acid and carbonic acid gases or vapors are evolved, and hydrogen and oxygen supplied to the cylinders at will, the supply being regulated so that correct proportions of each will be available during the period of corrosion.

The particles of lead sand, being so very small, are quickly acted upon by the corroding agents, as the slowly revolving cylinders keep this fine sand in constant motion so that no part of it can remain unexposed to the direct action of the attacking vapors, the particles constantly changing their location and presenting new faces to their attacks. Thus in a few days is accomplished what would have required months by the older system.

The cylinder system excels the stack system in more ways than one. The corrosion is more perfectly done, and there remains but a very small percentage of "blue" lead — as the uncorroded lead is called — compared with the other system. To all intents and purposes, it might be called a complete corrosion.

As most of the condemnation of the white lead produced by the cylinder system can usually be traced to those financially interested in the white lead produced by the older system, one should take such statements with the allowance of a grain of salt, and discount them to their just values.

It is presumable that poor lead can be and is produced by both the stack or cylinder systems; and again, that good lead can be made by both. If a lead is perfectly white, fine, free of surplus moisture other than that which chemically belongs to it; if it has good opacity and excellent working qualities, — we need have no hesitation in using it whether it has been made by one or the other method.

Properties of White Lead

White lead stands head and shoulders above any other white pigment — in so far as opacity or covering properties are concerned — when ground in oil or japan. Consequently it is used more than any of the others; in fact, much more than all the others put together several times over. Its working qualities under the brush are superior to any others, this being caused by the white lead combining chemically with the linseed oil and forming a linoleate lead soap which works freely and smoothly under the brush, enabling the painter to apply it evenly with a minimum amount of labor.

It is not alone useful as a white pigment for painting surfaces in its own or self color, but it is used to even a larger extent as a base upon which all the lighter tints are made by addition of coloring matter.

Were it not for a few defects, white lead would certainly be *the ideal white pigment* instead of being only *the most useful one*. It has already been hinted that a lead which contains too much hydrate of lead in its composition would be somewhat deficient in opacity, and that if it contained very much more than two thirds of the carbonate it would be likely to chalk badly, or worse than the ordinary. No matter what the proportions of hydrate and carbonate the white lead may have in its composition, in time *it will chalk* if exposed to the action of the elements.

In the best leads the process of disintegration (for that is what chalking means) commences in about one or two years after its application, usually in an inappreciative manner, and continues until in time one can rub it off the building by simply passing the hand over it. As stated, this chalking is very gradual and hardly noticeable at first. The chalking can be hastened or retarded somewhat by the improper or proper use made of the binding vehicle; also by the improper or proper admixture of other pigments.

White lead is a good drier of linseed oil, and requires but a very small admixture of artificial driers to hasten its drying; and out of doors, excepting in cold or wet weather, none are needed. Driers seem to kill the elasticity of linseed oil, and to hasten its decay, so that when used at all in connection with white lead, it should be done with very modest doses.

Only raw linseed oil should be used with white lead for outside painting. The raw oil is much more elastic and

penetrating than the boiled, nor will the chalking commence as soon when it has been employed than it would otherwise.

The greater the quantity of raw linseed oil that can be incorporated with the lead and make it cover fairly, the longer the time before chalking will begin. It stands to reason, therefore, that as a small proportion of volatile oils should be used in outdoor painting in addition to raw linseed oil as will accomplish the legitimate end in using it at all, *i.e.*, of rendering the paint more fluid and of making it set more quickly. The above applies with even greater force to the last or finishing coat, where volatile oils should be dispensed with entirely wherever possible to do so. It is somewhat harder work to properly spread paint so mixed,—that is admitted,—but it can be done. White lead seldom chalks upon inside work that is not exposed to the weather, and what has just been said is not applicable to indoor painting.

White lead is injuriously acted upon by the action of sulphureted hydrogen vapors, which will quickly turn it black. That gas converts it into the black sulphide of lead. This will sometimes occur in a single night, therefore its use should never be resorted to in localities where this gas is likely to develop.

There is one grade of white lead which is best known as *flake white*. It differs in no wise from ordinary lead excepting in that it is a selected white lead. The flakes which drop off the buckles corroded by the stack system, have given it the name. This outer covering of the buckles is superior in opacity to that from which the flakes fell off and which comes next to the core or uncorroded lead that is more imperfectly corroded, and which in ordinary lead is averaged with the flakes and forms the white lead of commerce. Therefore *flake white* design-

nates a quality of white lead of superior corrosion and which possesses extra good body.

The same objectionable features enumerated as appertaining to ordinary white lead, apply to this with as much force. It is used mainly by decorators and sign painters for striping in car shops and carriage factories, for coaches, buses and wagons, — in fact, wherever an extra good-bodied lead is demanded.

Every nation has its own system of packaging, grading qualities and marketing white lead, therefore one will not find the same rules nor trade customs in the United States as prevail in the United Kingdom, nor upon the continent of Europe.

In the United States an unwritten law has developed which says that upon all packages on the label of which the manufacturer's name is placed and the words "Strictly Pure" are used — that the contents of the package are free of any adulterating material and contain nothing but pure white lead ground in pure linseed oil.

It is, however, true that some jobbers mark some fake leads as *strictly pure*, which are far from being so and which are adulterated to the bitter end; but then, they withhold from them their own names and adopt some flaring name or label which misleads no one aside from the unsophisticated and ruralists who wish to buy pure lead at half its market value.

So if a lead package put up in the United States bears no corroder's name nor the legend "Strictly Pure" upon it, one may take an oath and swear that its contents are adulterated. He can do so without ever having seen an analysis of it, and without the least fear of committing perjury. None such is pure. It is an adulterated lead, or what is known as a compound lead.

It is not within the province of this treatise to enter into an endless review of the merits or demerits of compounded leads, nor of the superiority and better wearing qualities claimed for them by their manufacturers over that of the strictly pure.

There can be little doubt, that proper combinations of other pigments with white lead are beneficial for many purposes. The painter should be well enough posted to do this compounding himself to suit the particular job upon which the compound is to be used. Certain compounds or combinations of pigments are better adapted to sundry conditions than they are to any other; and no ready-prepared compound, even when honestly made after a uniform formula, is likely to meet his requirements fully in this regard, however good it may be for *the right place*.

A man well posted upon the various qualities and defects of the white pigments should be able to pick out the proper corrective ones to combine with white lead to suit any job. If it be old, open or spongy, it certainly will require to be treated differently from a surface which is close or non-absorbing.

There are, no doubt, very good lead compounds upon the market which will give desirable results for painting under certain conditions to which they are admirably adapted, but which will cause some trouble and always mortification elsewhere. As a rule, there is no real advantage to be gained from their use. They are not as economical as those similar in composition and compounded at the shop from strictly pure white lead and other correctives bought as such.

Barytes, or the native barium sulphate (heavy spar), plays an important function as an adulterant of white lead; for that matter, it does in the adulteration of nearly

all other pigments. But it is preëminently adapted as a makeweight for white lead: its heavy weight comes nearest of any other to that of white lead. Its transparency, too, in oil is another reason why that substance is so well adapted for the purpose of its or any pigment's adulteration, because it will not discolor them. More will be said regarding barytes under its proper heading, and the reader is referred there for the particular details and characteristics belonging to that pigment. The one object why it was entered into here is because it was necessary to point out the main source of adulteration in connection with the "off brands" of white lead as are best known and called all brands of lead that are not strictly pure. Compound leads which are sold as such, are not included in the "off brands," but are known in the trade as "*compounds*."

Compound leads are not necessarily adulterated leads, because in the first place they do not claim to be strictly pure lead. They are legitimate articles of commerce, and stand upon their own merits. Painters buy them with a full knowledge of what they are, and from having had some previous experience with them, which in some instances has been well paid for.

The same substances which may be used in a legitimate way in a compound lead, and of whose presence the buyer is well aware, may be and are rightly called adulterants when combined with lead which the purchaser is led to suppose is pure white lead.

For this reason, gypsum, china clay, carbonate of lime, or even the sulphate of lead, which are all used in the adulteration of white lead, are not such when the purchaser buys a compound lead, as the attempt is not made to parade them as something which they are not.

LEAD SULPHATE

This lead salt is never sold under that name in the supply stores. It is only within a comparatively short time that it has come to be talked about in connection with paint or mixtures of paint.

It is a by-product of several industries, and until lately it has had but little commercial value other than that which inherently belongs to it, as, if it could be reduced to its metallic form, it would be worth the price of metallic lead less the cost of conversion, which is expensive.

It can be readily made by simply adding sulphuric acid to the solution of a lead salt; then it becomes precipitated as a white powder which is insoluble in water and absolutely so in alcohol.

Its insolubility makes it non-poisonous. If it possessed a good body, or, in other words, had it more opacity, it would be a very desirable pigment. It is not as pure toned a white when ground in oil as is white lead. It is not readily affected by the vapors of sulphureted hydrogen. Its chemical formula is $PbSO_4$.

Sulphate of lead is never used alone as a pigment, but as an adjunct to some brands of white lead, and largely so in ready-mixed paints. Its chief use in paint material manufacture is for such grinders as put out a brand of white lead which they mark as strictly pure. It enables them to place a product upon the market for which they can vouch as strictly pure lead, but is no more entitled to be so called than sugar of lead would be. When sold as "strictly pure" lead, sulphate of lead is as much entitled to be called an adulterant as barytes, or any other substances which have no business to be there.

It is used advantageously in color making — such as the lemon or canary chrome yellow — but in the above they are really the result of the use of sulphuric acid in the making of the color, and not because they are placed there.

SUBLIMED LEAD

Sublimed lead is a certain form of sulphate of lead which is obtained by sublimation in Southwestern Missouri, and to which much of what was said of sulphate of lead proper does not apply. While it is still somewhat deficient in opacity as compared with hydro-carbonate white lead, it comes next to it in that respect, and is used extensively by mixed-paint manufacturers in preparing those goods.

It is basic sulphate of lead; contains about one fifth of lead oxide and about five per cent of zinc oxide — the ores from which it is made containing zinc in combination with the lead. It is sublimed in a manner somewhat similar to that described under the heading of Zinc White.

One property entitling it to consideration is its non-poisonous character. Another good point is that being an oxysulphate of lead it is not subject to turning black by sulphureted hydrogen gases, and is so extremely fine that it does not settle readily in an oily vehicle. It is also very white when mixed in oil, which cannot be said of sulphate of lead.

DAHL PROCESS WHITE LEAD

This form of lead pigment is obtained by precipitation. By a modified method of manufacture, it is much superior to the product obtained originally. In this modified process it is first reduced to a downy or feathery state, after which it is placed in stationary tanks where it is sub-

jected to the action of dilute acetic acid which converts it into a basic acetate of lead. The solution is subjected to the action of a stream of carbonic acid, which, as already said, lead having more affinity for it than it has for acetic acid, combines with it, and is precipitated in the form of basic carbonate of lead.

It differs from Dutch and similar process leads in that instead of being crystalline it is amorphous in its particles. It therefore does not possess quite so much opacity, but is a greater absorbent of linseed oil. Naturally from its amorphousness it is very fine, and runs uniform in composition. It is, however, too soon to form a decided opinion of its merits, whatever it may present theoretically.

WHITE OXIDE OF LEAD.

Periodically somebody or other discovers — or rather thinks he does — something new in a white pigment of lead derivation which in his estimation is sure to displace the hydrate oxide of lead, and that his discovery is sure to fill the “long felt want” of a pigment — one that is white, non-poisonous, not injured by noxious gases, and for which they claim a string of virtues too good to be true and too numerous to mention. These great discoverers appear as regularly as the seventeen-year locust, and the wreckage of the last of them is hardly cleared away before somebody else turns up ready to launch out a new venture which proves similar to the ones which have gone before; but as it is launched out under a new name, it takes a little time before it is recognized.

It seems that some people will never learn that oxides of lead all have the property of solidifying into a hard

mass inside of the package containing them in the shape of a ground paste, if ground with linseed oil. Yet one after another of the discoverers seems to be able to enlist men with capital to back their foolish ventures, and men of good business capacity and caution in other respects try to accomplish the impossible — *i.e.*, grinding lead oxides with linseed oil.

The white oxide, the monoxide (litharge), the dioxide (red lead), the teroxide (orange mineral), all have the same peculiarity of solidifying in time when ground in linseed oil. When the retailers who are not posted, have keg after keg returned to them after a few months — with occasionally a claim for damages — it proves to be the beginning of the end for “oxide of lead” in that locality.

Some in sheer desperation have gone so far as to grind it in soft linseed oil soap, as, when ground in that, it remains in a smooth, soft paste; but, as one could readily expect, it is soon found out and the “jig is up.” The history of defunct concerns in this connection would make good reading on short-sightedness for the rising generation.

There have been, and some firms are to-day trying, experiments with other salts and forms of lead. Time may prove some of value; none so far have any claim to superiority over the old hydrate-carbonate. All as yet have so many defects that the very grave ones admitted as belonging to white lead look small compared with them.

The Blowpipe Test

Adulteration in white lead and many other forms of lead is readily detected by the use of the blowpipe. This simple test is within reach of every paint dealer or painter. It is simple and easily made: A piece of soft charcoal, such as is made from willow, to lay the lead upon,

an ordinary candle or spirit lamp, and a blowpipe. This is simply a small metal tube curved at the end. The curved end has a very small aperture, and that is placed against the flame of the candle while the operator blows in the other end of it; this throws a stream of blue flame from the candle to the charcoal, or to that part of it rather where the lead is laid upon it, the operator holding the piece of charcoal in his left hand. The blowing should be regular and steady, and in a minute or two at most the oil will be burned out, and the white lead will be converted into a blue lead globule.

If it has been adulterated with lead sulphate, barytes or whiting, china clay, etc., the lead cannot be reduced to a metallic state by any amount of blowing. There will be a mass of dry white, yellowish or grayish color according to the adulterant, but no lead will show up. As small a percentage as 10 per cent of adulteration mixed with the lead will prevent its reducing; as no lead is ever adulterated with such a small percentage as that, there will be no difficulty in finding it with the blowpipe.

If the adulterant is sulphate of lead, it can be found by the great difficulty of its reduction; few men can use the blowpipe steady or long enough so to reduce it, as it takes much more heat to do so. That form of it mentioned as sublimed lead is practically irreducible by the blowpipe; it takes over 1200° F. So one may look with suspicion upon any white lead that does not readily reduce in two minutes.

One can form a good idea of the purity of lead by putting a little of the lead paste upon a sliver of pine wood, and burning a match or two underneath it. If it is pure, little globules of metallic lead will appear in the paste, which will not be the case if the lead is impure.

The blowpipe test is valuable only to test the purity of hyd-oxi-carbonate of lead—the white lead of commerce. It will not apply to many of the white salts of that metal, as some fuse only at extreme temperatures or by the use of fluxes which none but experienced men can conduct successfully.

The present tendency in some quarters to recognize as "white lead," in a commercial way, the basic sulphate of lead or sublimed lead would of course nullify the test; but why, if, as claimed, oxy-sulphate of lead is superior to Dutch process hyd-oxi-carbonate—the standard white lead of commerce—should it seek to shelter itself under the name adopted for an entirely different pigment?

Will it not be better for both to retain their present designations which have a definite meaning, and if sublimed lead proves itself the superior, it should be entitled to a distinctive name by which purchasers can purchase it with a certainty that it has not been adulterated with Dutch process lead, and it should not seek to shelter itself under its time-honored appellation?

The above is written not as a disparagement or as an indorsement of one or the other forms of leads, but in hope of saving the white lead and sublimed lead industries from future confusion, whereas now the two are distinctly known and recognizable under their commercial cognomen.

CHAPTER III

WHITE PIGMENTS (*Continued*)

ZINC WHITE

History

ZINC WHITE as a pigment is of much more recent origin than that of white lead, and does not date back much farther than threescore and ten years. It was known before that, and it had been used in water colors a few years previously. As an oil pigment, however, it may be called a recent one. It would in all likelihood have been used for years before it was, but for the difficulty encountered in making it dry properly; and writers in the beginning of the nineteenth century incidentally mention the probability and possibility of its becoming a useful pigment. However, it was in the forties that it was first used as an oil paint with a drying oil by Leclaire in France. From that time to the present, its use has steadily grown and extended.

It took a long while at first to break down the prejudices then existing against its use, and which even now prevent many from using it. So the advent of this pigment to popularity has been slow. It has had a hard time to establish itself firmly.

Chemistry and Manufacture

There are two very distinct qualities of zinc white. The better quality is known to the trade as "French"

zinc, and the other as "American" zinc; both have the same chemical composition,—*oxide of zinc*.

French zinc is that which is made from the zinc metal, while American zinc so-called is made directly from the zinc ore. It will be seen that the terms used to designate these two qualities are more arbitrary than strictly true—at least, such is the fact to-day. It does not do America justice to call the poorer zinc after it, but, as we have seen in the case of Cremnitz white, names stick. No amount of reasoning is likely to change it any more than in another glaring instance, *i.e.*, English and American Venetian red.

The French are no doubt entitled to the honor of having first used this valuable pigment; also of having first produced it in a commercial way; so that importers, brokers, and paint manufacturers gave it the name, and habit still forces the name to remain. France never had a monopoly of its manufacture, and Belgium produces one of the most esteemed of its brands—the "Vielle Montagne" zincks.

Within the past twenty or twenty-five years, works have been established in the United States which are producing zinc oxide by the "French" process which is certainly equal in quality to that made in any country. It is sold as "French" zinc, and the grinders pay as good a price for it as for that which is imported.

The process of manufacturing zinc white is very simple. The metal is vaporized by heat in retorts, whence it is carried to a chamber where the vaporized zinc comes in contact with air containing *oxygen*, for which element it has a great affinity. It combines with the oxygen, and is at once converted into an oxide of zinc. This oxide of zinc is gathered into a series of sacks or small chambers suspended with the mouths opening

downward. That which is lightest and whitest is deposited farthest from the point of entrance of the vapor; the heavier is also the darker and is deposited nearest. This darkness is caused by impurities consisting mainly of unconverted metal, which prevent the grading of the zinc white as first quality.

Zinc oxide made thus is very light and flocky, resembling in a manner snow or eiderdown. It is selected and graded according to quality, whiteness, etc.; after which it is submitted to the action of powerful compressing machinery under intense heat; then it becomes the article of commerce known as "Dry Zinc White."

Vast quantities of it are annually consumed in that shape for distemper work, for the better class of kalsomining, etc.; either alone as a white, or in combination with whiting or gypsum or with coloring matter in the making of certain tints.

For use in linseed oil painting, it is ground either in a strong drying oil which has been previously treated to discolor it, or in drying poppy seed oil for the finer grades of work.

It is usually packed in tin cans ranging from one to twenty-five pounds each. Both the French and the American zines are sold in two qualities according to their whiteness. The whitest and best is sold as *Green Seal* zinc white, while that which is of a darker shade is sold as *Red Seal*. These are usually found in the output of all grinders of zinc, and they have come to be understood as meaning first and second quality. They are used upon all grades of zinc ground in linseed oil or poppy seed oil, except upon the very lowest and cheapest grades of American zines, which, in addition to being of poor zinc, are usually adulterated.

American zinc is made in precisely the same manner as that described for French zinc, with the exception that instead of using zinc metal, zinc ore is employed in its place. It is made from the vaporization of the ore, the oxidation being the same; the process in all respects being identical, and so are the after treatments.

From the impurities contained in the ore, one may well surmise that the product cannot be equal in either whiteness or quality to that made from the metal itself. Both systems are now used in the United States, but, as stated before, it is only in recent years that it has been made here from the metal.

The chemical formula of zinc white is ZnO. It is the only oxide of that metal and the only one of its many salts that is of any use as pigment to the painter.

Tests for Purity

The purity is easily tested. If it is in a dry powder, it will dissolve readily without effervescence in either dilute nitric or hydrochloric acid.

If it has been adulterated with barium sulphate, that substance will not be acted upon by the acids. It will be left undissolved in the shape of a white powder at the bottom of the dish. If there is effervescence during the dissolving of the zinc white by the acids, the presence of lime in the shape of carbonate of lime or whiting is plainly indicated.

If the zinc to be tested is ground in oil or varnish, it should be agitated thoroughly in benzine or naphtha, which will dissolve the linseed oil out of it. Let it rest and deposit after the agitation has been thoroughly done, then pour out the benzine and repeat the same operation until it is thoroughly free from the oil. After drying the powder — which will be done quickly if left in the open

air — it can be used in the test precisely as was described for the dry zinc white.

Zinc white is not affected by sulphureted hydrogen gases, nor by sulphurous vapors of any kind.

Properties and Uses

Oxide of zinc, or zinc white as it is best known to the paint trade, has had its praises sung to all kinds of tunes in every civilized country where paint is used. It deserves a good deal of this admiration, and is one of the most valuable additions to the list of white pigments, and really is indispensable in the well-regulated paint shop. It should be used as a component part in many a mixture. But much of the praise we hear should be carefully weighed and conclusions slowly reached. It will hardly do to swallow the whole of the flattery, at least not to the extent some would have it, that of discarding the old standby, white lead, and substituting for its use that of zinc white. While some of its friends are extravagant and unquestionably go too far, it is nevertheless an excellent pigment in its proper place. When judiciously used, it is invaluable, and will give every satisfaction. If used, as it sometimes is, in a haphazard, hit-or-miss sort of way, it will not take many years before sorrow will come of it, and the painter's reputation goes a-fishing.

For interior work in either distemper or enamel, zinc white is greatly to be preferred to any other white pigment, and its praises may be sung in a very high pitch. Then it deserves the homage of every painter and decorator in the land. Its freedom from the attacks of white lead's greatest enemies — sulphurous fumes — compels its use under all circumstances where these are present.

It is true that the French government is throwing its influence in favor of the use of zinc and discouraging the use of white lead, and has passed some very stringent legislation in regard thereto. Simmered down to its real value, this means that journeymen painters in that country, either through bad habits or careless use of white lead, are more subject to lead poisoning than those of other nations. These have circulated petitions, held mass meetings, and have forced upon the attention of the government what they choose to call "the evils of white lead." The legislation in a great measure is the result of this agitation. True, nothing but zinc can go on to public buildings, etc. This is heralded and made use of to the limit, by those most interested in its manufacture and sale; nevertheless, when all the facts in the case are fearlessly looked into, it means but little.

All public buildings, and nearly all others of any sort, are of stone in France. The painting is principally that of the interiors and some of the doors and blinds, which are usually painted in colors and not with zinc on the outside. Some few are painted white, or in tints made from white zinc as a base, and they show very plainly that had the government been as careful to take the advice of more practical men instead of that of theorists, and had not to knuckle under the goods handled by the journeymen who are *voters*, and their friends who are voters too, there would be less cracked paint to be burned off than there is to-day and will continue to be. It is only a question of time when the practice will have to be abandoned, as the French are no greater lovers of eyesores in the shape of paint scales than any other people.

The particles or atoms of zinc white have a great affinity for each other. As has been already related

when describing the manufacture of zinc white, the atoms cling together like snow or eiderdown interweaving each other, and that they are compressed by powerful machinery. This adherence and brotherly embracing of each other in these atoms is remarkable, and stands as the very opposite of that of the atoms of white lead, which have no affinity whatever for each other. This in part explains why lead chalks so easily. When the binding of the linseed oil which holds the atoms together begins to decay, they begin also to drop and loosen from each other — they fall singly, having nothing to hold them.

The reverse condition takes place with zinc white. Its atoms have such an affinity for each other that they hold together in a solid mass. When the oil has so decayed that it can no longer bind the zinc and hold it against the building, the paint cracks and gradually loosens from it, forming a scale which will eventually drop away in a mass in the same way and manner as the bark does from the Buttonwood or sycamore tree.

While the use of zinc white alone for outside painting is not to be recommended, a combination of it in proper proportions with white lead will in a good measure counteract the inherent defects appertaining to each. The tenacity of the zinc white will retard the falling away of the white lead; and that, in return for the good deed done it, will help to prevent the excessive tenacity of the former.

There can be no set rule formulated giving the exact proportion that each should have in making up a combination. Under certain conditions, lead paint to which 25 per cent of zinc white has been added may crack and scale, while again under others as much as 60 or even 80 per cent would not affect it injuriously.

As this treatise is written for the purpose of giving information that concerns pigments, and not upon the application of paint, details therefore which properly belong to a book on painting cannot fully be elucidated here. Possibilities are indicated to show what the properties of the pigments are and how to correct some of their bad points. Generally speaking, therefore, a paint for ordinary surfaces should not contain more than 20 to 25 per cent of zinc to 75 or 80 per cent of white lead for outside painting. The figures given are conservative, and circumstances might alter them considerably.

The non-drying properties of zinc white have already been mentioned. It is therefore necessary to add some driers to the linseed oil used in its application. This is especially the more essential if raw linseed oil be used; and it is really the only one which should be employed in connection with zinc white for outside painting, on account of its greater elasticity, which lessens its tendency to crack and scale, by lengthening the period until decay commences.

For distemper painting, aside from its beautiful white tone when used alone, or the clearness of the tints made from it and the addition of coloring pigments, it has also a soft, satin-like finish impossible to produce with whiting or gypsum whites. Therein lies the secret of many a kalsominer, whose work is so much superior to that of others who do not use it and have not discovered its value. The former are looked for and kept busy while the latter are looking around for work. The clearness of tints made with zinc is not confined to distemper work, but is still more strikingly noticeable when tints are made from pigments ground in oil, and zinc white in oil or poppy-seed oil.

CHAPTER IV

WHITE PIGMENTS (*Continued*)

THE EARTH WHITES

General Remarks

EARTH WHITES are so named to distinguish that class of white pigments which owe their origin to mother earth in contradistinction to those which are derived from a metallic origin, as lead and zinc.

None of the earth whites are as valuable to the workman in oil painting; in this respect they are entirely different from the metallic whites. When mixed with linseed oil, they assume a dirty, dingy, measly-looking white. All are more or less transparent, or at best are semi-transparent. By themselves they may be called useless as oil paints, but, for all that, some are very useful when employed as adjuncts to the metallic whites in oil. Their usefulness lies chiefly in the correction of some defects, and that is their chief use in connection with that vehicle.

In kalsomining and distemper work they become true pigments in every sense of that word. They impart a color of their own to the other pigments with which they are mixed. In water, they are invaluable.

Lime, clay, and silica, with admixtures of other substances in small quantities, form the basis of nearly all the earth whites. According to which of them mainly enters into the respective compositions and predominates, they are known by various names.

Most all the earth whites are to be found in abundance in many parts of the world. Most of them are cheaply mined and prepared for use, consequently they are inexpensive. This cheapness makes them very attractive for compounding with white lead or zinc white, openly so in the goods known as compound leads, etc., or secretly so in the preparation of the "off" brands. The greatest harm that any of them do in either the off brands or the compound leads is that they reduce the covering properties in these in nearly the same ratio as the quantities into which they enter. It is said "nearly," but as some of these earth whites are semi-transparent and have covering properties of their own, it is true therefore in the main of most of them. Their spreading possibilities are increased, and pound for pound they spread farther than lead, so that a greater number of square yards can be painted with a given weight. This is due to the fact that they absorb more linseed oil than does white lead. This makes them wear longer, and helps to protect the lead in the combination. Some of these earth whites have strong caustic properties; this causticity saponifies the linseed oil, and as the saponification formed is a partially soluble one, it is necessary to be careful of their use.

CARBONATE OF LIME, OR WHITING

Chemistry and Source of Supply

Carbonate of lime, or whiting as it is popularly called, whose chemical formula is CaCO_3 , is plentifully supplied by nature in a nearly pure state in the shape of chalk. It is at least pure enough for use as a pigment after the removal of the coarser substances mixed with it, such as silica and other impurities, by levigation. It is sometimes made

artificially from certain varieties of limestone, which in the United States is more abundant than chalk.

The principal source of supply is chalk. That is the natural carbonate of lime. All it needs is crushing and afterward levigating.

Levigating is the technical name used to designate the operation of washing out the impurities present in all natural earth pigments. Whenever that word is used in this treatise in subsequent chapters, one will understand that it is employed to designate the washing out of impurities consisting of heavy sand, pebbles, roots, etc.

After the chalk has been crushed or powdered, this is mixed with water and thoroughly agitated, that it may all be dissolved and held in suspension by the water. It is then run off, conducted through pipes to a succession of vats where the liquid mass overflows from one to the next, and so on. The finer atoms being the lightest they are held in suspension the longest, and they flow to the farthest vats before depositing, the sand and other heavy impurities settling in the first ones, so that the quality of the settlings increases or decreases according to the longer or shorter distance of the settling vats from the first of these where the outflow starts.

The first, second, and third vats contain nearly all the worthless substances, which are usually thrown away. The rest are graded according to fineness. The pulp is then dried, crushed in large lumps or powdered, packed in barrels, and the last is sold as "Gilder's" whiting-chalk which has simply been crushed and powdered without having been subjected to the levigating process is known by the name of "Commercial" whiting.

The qualities and styles of packages which a few years ago were to be found upon the market under various fancy names have nearly all disappeared. For in-

stance, the small cones of Spanish white, the brands of Paris white, London white, etc., are seldom to be found.

Some decorators prefer what is known now as "lump" whiting. This is not lump chalk, as some might suppose it to be. That would be too hard to dissolve,—in fact, it would not dissolve; besides, the impurities lump chalk contains would bar it from use by that class of workmen. Good lump whiting is the same as the best grade of gilder's whiting, with the only difference that after the levigated pulp is dry, instead of being powdered it is simply broken up into chunks for the handy packing of it in barrels.

That it is better than the corresponding quality that has been powdered, is claimed by some decorators. It is a question requiring a Philadelphia lawyer to decide. It is too hard for the ordinary mortal to answer. It is a remnant of the times when the old bosses used the dabs of Spanish white, which were just pulp dipped out and dried in cone-like shapes, and were in those days known to every painter in the land. But to-day, with powerful machinery to crush the whiting, and if this has been well levigated, it looks as if the powdered whiting had the best end of the arrangement. It dissolves in water more readily than the lump, therefore is more desirable for the painter's use, because it saves his time.

Properties and Uses

Whiting is a very good distemper pigment, and is probably more extensively used than any of the white earth pigments. It is used chiefly by kalsominers, decorators in distemper painting, and in immense quantities by the wall-paper manufacturers in preparing their printing tints.

In linseed oil it is very indifferent, to say the least. From its causticity, it must be very active in saponifying and destroying the linseed oil. It never dries very hard with it, and where the oil has been applied thick, it will skin over the soft stuff underneath and will come off with but little provocation. It always imparts a dull, dirty tone to any tints made by adding coloring matter to it, or to white lead compounds where it predominates. For employment alone, its transparency is against it. Small quantities of it added to the megilp used by grainers will make the color comb better and permit it to be put on heavier, and still be more transparent than would be possible without it.

There are several cretaceous earths which at times have been used as paint or adjuncts to white lead, but none of them have proved very satisfactory. Their use is now obsolete. Far better substances can be had which are fully as cheap as whiting. The chief use of whiting is in water-color painting, and in this connection it is consumed in enormous quantities. The wall-paper printing industry uses it in the preparation of its tints. The kalsominers and fresco painters also are large consumers. The putty manufacturers also employ it in the preparation of that article.

CHINA CLAY, OR KAOLIN

China clay is the only white earth pigment that has any body in oil, but even the best samples could hardly be called semi-transparent. This class of white earth is also known under the general names of argillaceous and clay white. It varies greatly.

Properties and Uses

The kaolin, or china clay of commerce, is the best representative of the class. It is nearly a pure clay, and that

is why it is better bodied than the cretaceous or silicious earths. It is very much better than whiting as a component part of off leads and lead compounds. Nevertheless it is far from being an ideal substance; it has some grave defects of its own, but it has a better body, and is not an active destroyer of linseed oil.

Its defects are that it dulls the tone of white lead, and that it muddies that of tints in about the same manner and for similar reasons as whiting does.

It is also useful as a distemper color, working nicely under the brush; but as it does not make as smooth a job as whiting, it is therefore very seldom employed for that class of work.

Its chief use is that of an extender, as an adulterant in off leads or compounds, ochers ground in oil, Venetian reds, etc. Its greater body, heavier weight, and being much less caustic than carbonate of lime, render it much better adapted for purposes where these qualities count.

But in common with all earth pigments which contain a large proportion of clay or alumina in their composition, the great trouble is that clay has the property of absorbing water and of parting with it readily. This hygroscopic property is lessened when mixed with oil, but not altogether eliminated. After the oil has thoroughly dried, and from exposure and decay become porous, clay pigments absorb water from the atmosphere, and when the heat of summer comes, this moisture is given out. This is the main reason why so much trouble has been reported from the use of ochers. There is no doubt that in the majority of cases, this was due to the use of an ocher which contained a very large percentage of alumina in its base.

This constant absorbing or parting with moisture is bound to produce blistering, and later on scaling, and is

the principal cause of mildew. It also causes the sinking in of colors, which means a cloudy, fady, muddy, uneven-looking surface.

GYPSUM (SULPHATE OF LIME)

History and Provenance

Gypsum is plentifully found in the natural state — a soft rock — in nearly all parts of the globe. It is known to every one in its calcined condition under the form and name of plaster of paris. In this form, however, it is of little use as a pigment. It is therefore chiefly in its uncalcined condition that it will be considered.

It is first levigated and freed from impurities in much the same manner as has been related was used to clean chalk from its impurities. It is chiefly in this condition, after thorough drying, that it is useful either as an adjunct to other pigments, or as the principal ingredient in all the so-called anticalcimine, gypsine, etc., — the prepared distemper paints whose manufacturing headquarters are located in Grand Rapids, which is situated in the heart of the gypsum beds of Michigan.

Properties and Uses

For distemper purposes and water colors, gypsum is well fitted, although it does not work as smoothly as whiting, nor does it make as solid a covering. In some other respects it is superior to it; it has much better tenacity and adhering properties. It is better to buy it ready prepared for application. It requires a long experience in its preparation. This the manufacturers possess; and experimenting continually, they have been able to correct some of its faults and to put out a line of

goods which is much better than any thing the painter could possibly prepare for himself.

In relief work gypsum is the principal substance used in the mixtures.

It is also useful in oil, not so much as a pigment as an adjunct; as a corrector or betterer, if it may be so called.

It has some of the defects of other earth whites, the main one being its transparency. It possesses no opacity in oil, or next door to none. When used excessively it dulls tints the same as the rest of them. Unlike many, it has no causticity, so that it does not injuriously affect linseed or any other of the fixed oils. Therefore when used judiciously with white lead, it will retard its chalking, for it is a good absorbent of oil, and is inert. But it must be used in reason, or it will make the white lead look off-color and too transparent.

It is also used by color makers as a base for certain colors, but of that more will be said as occasion will require under the proper heading. It is chiefly in that connection that its usefulness lies.

Chemistry

Sulphate of lime when calcined at a heat of 110° C. loses its water of hydration and forms the well-known article of commerce, plaster of paris.

In that condition it absorbs water readily and recombines with it, returning to its hydrate or natural condition. This renders it unfit for use as a pigment, as it would harden when mixed with the water used to thin it in distemper work, and would absorb enough moisture from linseed oil, which contains a small percentage, and from the atmosphere, which at times is heavily charged with it, to harden even when ground in oil. When it has become heated to 500° C. then it loses the power of

absorbing moisture, and it is in that condition that it has to be for the purposes of the manufacturer of pigments.

It is never found in that shape in a commercial way, and for that reason the painter cannot avail himself of its use in order to compound it with other pigments.

Should the future demand for gypsum of 500° C. be found to grow, it is highly probable that manufacturers will grind it in oil. At the present it is known only to few aside from the color makers, so there is no market demand for it. Probably the reason is that it is a very hard substance to grind after such high calcination. When it enters in combination with other pigments it is much easier ground, and it is always in that shape that it is ground.

SILICATE EARTHS (SILVER WHITE)

Properties and Uses

Silver white is known to most painters, probably not as a paint or pigment, but as an ingredient entering into the preparation of fillers.

It is hardly worthy to be called a pigment, as, even when mixed with water for distemper work, it shows but little opacity, and is very inferior to either the cretaceous or the argillaceous earths for that purpose. The chief use is in correcting some of the evil tendencies and defects of white lead and zinc white. As correctives, then, the silicate earths are excellent, and are better adapted to that purpose than are the earth whites of either of the two classes described before. Their benefit is great, and the time is not far distant when a paint will hardly be considered perfect that contains no silicate earth in its composition.

The above statement may be considered by many as claiming too much, and it may possibly be so; for it is really possible to make very good paint without it, but such was not in mind when it was uttered. The cost of making a good paint without its use being greater, the chances are that there would be but few so made, and so the truth contained in the statement remains anyway.

Composition and Chemistry

Silicate earths, as may well be surmised and as the name indicates, are mainly of silica or sand; but this is so fine and the atoms so minute, that in the best grades of it, they are held in suspension in liquids a very long time before precipitation takes place — the particles will almost float.

The silicate earths occur in various parts of the United States in natural beds, and for once Dame Nature has endowed America with an earth useful in painting which is superior in fineness and quality to anything that has been found so far in any of the European or Asiatic countries. The products of American mines are exported extensively. That will never be the case with its other natural earth pigments, such as the ochers, umbers, and siennas.

The beds containing silicate earths are mined like all the other earth beds, according as to whether they lie near the surface or are located quite a way below it. The raw earth is levigated to clean it from heavy sand and other impurities, for while it is nearly of the same chemical composition as sand, — which is another form of silica, — that is as much of an impurity in a silicate earth as that same sand would be if found in an ocher.

In some of the beds of silicate earths the product obtained is said to be so nearly pure and free from foreign matter as to hardly require levigation to fit it for use.

It is again repeated that silicate earths are really not pigments in the sense that these can or do impart color, and their usefulness as correctives and for compounding with other pigments is their chief claim.

Silicate earths have no affinity for water or moisture, and are absolutely inert when mixed with linseed oil, nor will they injure it in any way. The atoms are so very fine, that they mix intimately with those of either white lead or zinc white to the great benefit of both of those pigments. They will dry hard without any tendency toward chalking, cracking, or peeling off, and, but for its lack of opacity, would be as near the goal of being an ideal pigment as can be well conceived. Its use should become more popular than it is now for all kinds of outside painting.

Its value can be inferred by what can be noticed almost anywhere, or by making the experiment for one's self any day. Take some white lead, or white lead and zinc, either in the pure white or with color added to make any tint, and paint the side of a building with it afterwards, and while the paint is still fresh, sand half of it, then notice what the consequences will be — say in five years. The unsanded lead will be in a bad state of chalking; the lead and zinc will be in a better condition, but still will begin to show signs of decay; while that part which has been sanded will be on as tight as the day it was put there. The *silica* did it. This is invariably the case; and as it is a common practice for many places exposed to being marred or defaced to be sanded, one will have little trouble to find samples of it already so painted which have been put on for many years. It can thus be seen and the results ascertained without having to wait several years for it.

The good wearing qualities of the French and English ochers are due to their being silicate ochers; they contain

a large percentage of silica in their base. (See the chapter on ocher.) Had the silicate earth but the opacity of white lead, it would be worth its weight in gold, as the saying is, as a pigment for general painting; but it has not that quality.

Many of the most valuable colored pigments are natural earths containing a large percentage of silica in their composition, which will be properly noticed under the several headings to which they respectively belong.

BARYTA WHITE (BARIUM SULPHATE)

Composition and Provenance

Baryta white is better and more commonly known as barytes in the United States. It is found commercially of many different grades and qualities. It is obtained in its natural state in many parts of the world. It is well known under the form of "heavy spar," which is a heavy crystalline rock. It is found in localities of many-varying geological formations. Near Quincy, Illinois, it is in large quantities in the limestone formation of the bluffs along the Mississippi River, also in the Blue Ridge region of Virginia and elsewhere. Again, it is found in the zinc and lead mines of Southwestern Missouri, Northwestern Arkansas, Southwestern Kansas and the Indian Territory. It is somewhat ludicrous, this finding of it in connection with lead in mines — as if that substance knew that later on it should be made to parade as and become a still closer neighbor of lead under its new form of "white lead," and made to renew an acquaintance with its old neighbor where they had lain together for ages before being disturbed from their peaceful slumber by the miners.

Properties and Uses

Barytes is very transparent. It is the ideal transparent pigment element, heavy spar being nearly as transparent as glass. When ground in linseed oil, ordinary barytes has no body. This can be best seen by the mixing of barytes with oil, and of painting a board three coats with it, the same mixed to the usual consistency of paint for a like purpose. It will be found that these three coatings, which had they been mixed from any of the usual pigments would have covered the board perfectly, in this instance have not even hidden the tracery of the grain of the wood. It will be safe to say that one single coat of white lead would have covered the surface of the board more opaquely than five coats of the barytes paint would do.

That barytes must be a very heavy substance may be surmised from the great weight of the heavy spar from which it is prepared. It is by reason of this heavy weight that it is the chief adulterant used to doctor up white lead. It being nearly of the same specific gravity, it is thus admirably adapted to pass inspection where the lighter weight of better adulterants would be a "dead give away" on account of the greatly increased size of a package of a given weight. That is why whiting, gypsum, etc., are so seldom used for the purpose of adulterating white lead. They would make entirely too much bulk, and the fraud would be recognizable to a novice. Therefore barytes has almost a monopoly as an adulterant of white, its heavy weight entitling it to that eminent position. Another requisite which is of as nearly as much importance, is that of its great transparency. More barytes can be added to white lead without muddying its color, than of any of the earth whites of better body,

but which change the color of the pigments they are added to, as has been already said of them.

Barytes is also the adulterant chiefly used in the making of the cheaper colors in oil; this, however, more on account of its transparency than that of its weight; as for many of the lighter-weight colors it is greatly against it, — it makes the package look too small. Its transparency usually decides the scales in its favor, as the chief make-weight adulterant even for the light-weight colors, some very light-weight adulterant being used in connection with it to give more bulk. Its transparency does not greatly affect the tone of the darker colors with which it is used; and while it can be detected when the adulterated color is used in making tints — it renders them less clear in tones — it will hardly show in the color itself in self-color painting.

In such extra light-weight colors as Prussian blue, lampblack, etc., it cannot possibly be used alone, as it would be an easy "give away;" so, as was said, it is usual to marry it to a much lighter-weighted partner, but it goes in just the same.

To show the capacity of barytes as an adulterant and its transparency, fifty pounds of it can be added to one pound of dry Prussian blue medium chrome yellow or lampblack without changing the colors greatly. Thus the enormous quantity of fifty to one is within the possibilities in adulterating with it. While seldom used to that extent, it is sometimes found in nearly that ratio in the "cheap John" lines of colors in oil occasionally to be seen — frequently more in the cheap dry colors.

While upon the subject of adulteration it might be well to say here that in a general way colors are not adulterated to anywhere near the limit of the possibilities as that of fifty to one. More frequently the adulteration

will be found to be one to one, three to one, or four to one of the genuine color; the latter being the common one in use, and recognized as justifiable for the proprietary greens and many other colors which do not indicate purity by any such claim upon their labels. This adulteration is, however, to such an extent, but will be found in many whose labels would, to the unsophisticated, create the impression that the colors were pure — without saying that in so many words.

As it is mainly as an adulterant that barytes has any serious claims upon the attention of the readers of this treatise, this is the side from which it is viewed.

Not so, however, of the artificially prepared baryta white, which is better known to artists and decorators as "*blanc fixe*." The latter is an excellent pigment for water-color painting, and nothing of what has been said of the natural barytes applies to that, except its lack of opacity in oil; but even in that, it is head and shoulders above the ordinary barytes. In water-color work, it possesses a good body. It is a perfect white, absolutely unalterable under all and any circumstances or conditions. It is insoluble in the acids, and is not attacked by sulphurated hydrogen gas nor any other sulphurous vapors. It is of great value for uses wherever the painting is subject to such influences where most of the other whites would be unsuited. Its absolute permanency recommends it for the highest grade of decorative work, and where the reputation of a man depends upon the intact preservation of his work. It cannot be too highly prized.

It has another very important qualification aside from those of permanency and whiteness, in that it has a peculiar texture that is entirely its own, and this remains even in the tints made by its use. The same pleasing

peculiar finish cannot be reproduced with anything else, no more than cotton can be made to have the feel of wool.

The artists and decorators are the ones who are mainly interested in its use. It is never likely to pass into the hands of the general house painter.

The reader should remember to distinguish between *barytes* and *barya white* or *blanc fixe*. Dr. Dudley, chief chemist of the Pennsylvania railroad, has had a great deal to say of it, and is probably as good an authority upon barytes in all forms as can be found the world over, he having made that substance the subject of much investigation and experiment. He says that some forms of the atoms in certain grades of barytes are scale-like, and overlap each other in such a way as to intercept the rays of light, and that when colored up with proper pigments the barytes does not show transparent. The doctor must have come across a brand that is hard to obtain outside of Altoona. The author has never yet seen it, nor has he ever seen or heard of any one else who has seen it in such a shape.

There is a legitimate use for barytes as an extender, especially in such colors as the greens or chrome yellows, which in their pure state are very strong. That statement should be understood in this sense only: For instance, one pound of pure chrome green or chrome yellow is worth, say, 25 cents per pound. Another one containing 80 per cent of barytes can probably be bought for 12 cents. Now for solid painting the last will go about as far as the pure, and cover the surface well. The latter will be the cheaper for this use, so the extended green or yellow is the most economical for solid painting. Where colors, however, are bought for the making of tints, and where the amount of coloring matter they contain is the

one thing most needed, the pure color will always be found most economical.

The above concludes the list of useful white pigments.

Many others have come up from time to time, staid a little while and were found wanting, or of less value than these which have been noticed in the two preceding chapters. They have about all disappeared, and the list of them would read too much like an epitaph, and would be a needless burden.

CHAPTER V

YELLOW PIGMENTS

OCHERS

General Characteristics

YELLOW ochers are natural earths found abundantly in all parts of the known world. It is of small wonder then that among the most ancient and earliest attempts at chromatic embellishment that have been unearthed and brought to light as a result of searches made in the entombed remains of former civilizations, many objects are found whereupon ocher had been used by some prehistoric decorator.

This yellow was used in the making of many an ingenious design upon the covering of the Egyptian sarcophaguses. In America the Aztecs especially, and the wild tribes of Indians roaming the plains and mountains of North and South America, used ocher also in such decorations as they were able to design and execute.

The Aztecs being the better civilized of them all, one would naturally expect more and better decorative work from them than from the wild migratory tribes; and they have not disappointed expectation, as remains of their pottery and decorated household utensils will show.

In Asia, ancient objects of Chinese and Tartaric origin have tracings of it upon them. The Greeks and Romans used it profusely; and so far there has not been a nation

found, where the earliest attempts at decorations have been preserved, that ocher does not appear as one of the pigments.

Of its uses to-day little need be said. It is a household word, and its praises are sung by everybody interested in using it, let him be painter, decorator, or artist. After white lead, it is probably the one color that any of them could least afford to discard.

Chemical Properties and General Character

All ochers are compounds or mixtures of several ingredients or substances. The coloring matter they contain is due to hydrate ferric oxide combined with an earthy base which varies with each locality, and sometimes with every hill in the locality where they are found. They will vary very much in the same vein of the same bed. Different seams in the vein are often of diverse composition, and are sometimes separated in the mining operations.

There cannot be therefore any recognized standard nor chemical formula for an article varying as much as this does. They would have to be changed with each new sample that was analyzed.

Notwithstanding so many variations, ochers may be grouped into two general classes:

1. Those where the earth base holding the iron oxide is chiefly of silicate earth.
2. The remaining ochers whose base consists principally of clay earths or alumina. There is a vast difference between these two classes of ochers, not only in the working qualities of each, but in their tones and permanency.

Then there is between the two classes mentioned above an intermediate one comprising such as vary in the quantity they contain of either silica or alumina, making

it sometimes difficult to class them properly, as they come to the border line of each of the main groups.

Mining and Production

Volumes might be written upon this one pigment alone without exhausting the subject matter. While it might be attractive to a specialist in colors, much of the matter would have but little interest to the general reader.

Ocher is mined and obtained from the bowels of the earth in many different ways, depending upon the depth required to reach it, or to the topography of the surface of the land. The price of labor and advancement in civilization, and the consequent use of labor-saving machinery, come in also as factors in the problem of mining. Sometimes shafts are sunk to it in level sections of country if the veins are deep. If, on the contrary, they lie near the surface, an open cut is made to the veins, and they are simply elevated, or, better still, a track is made and the ocher shoveled right into the car.

In the hill sections where it occurs as an outcrop above the valleys, it is tunneled out and loaded in small cars which are run out on a track in much the same manner as coal under similar conditions. In many beds, seams are found where for a few feet or inches a better grade of ocher is found than in the rest of the vein. If it be found to be very much better, it is shoveled out separately and handled by itself.

In its natural state, ocher is usually mixed with many impurities, such as roots of trees or plants, sand, gravel, etc. For the cheaper grade, or what is known as "unwashed" ocher, the earth after having been brought from the mines is simply sifted through a screen and barreled. Only the very lowest or ordinary ocher is sold

in that way, and the bulk of it is washed, and the very fine qualities re-washed; but with the system of continuous settling tanks it is seldom practiced any more, as the very finest can be obtained from the farthest tanks. This is equal practically to re-washing, and the method was described under the heading of "Whiting." It is needless to repeat it in this connection, as it is the same, there being no difference in the operation nor its principles.

As already told, the finest is that which settles in the tanks situated the farthest from the outpour, and the settlings are graded accordingly as extra fine, superfine, double washed, single washed, etc. These washings or levigations are no index to the quality of an ocher, and only signify the greater or lesser freedom from impurities contained in the ocher.

There is still another method of mining ocher, which is sometimes employed in hilly countries. A dam is built across a valley with a sluiceway at its lowest level, through which the water from the pond resulting from damming the valley can be let out or kept in by shutting the gate in the sluiceway.

After the heavy spring and early summer rains are over, the mining commences. Hydraulic machinery is used, and streams play upon the ocher beds in the hills adjacent to the valley. This dissolves them and washes down the earth into the pent-up valley below; after a sufficient quantity has been washed out, which is gauged by the capacity of the pond formed by the dam, it is allowed to settle. When the water has cleared, it is allowed to escape through the sluiceway, while the ocher remains as a pulpy deposit. It is left in that state to dry out by the action of the sun's rays. This requires some little time, and in wet seasons there is considerable risk attached to this method of mining; but there is usually nice weather

in the autumn, when it is taken advantage of to handle the ocher.

By this system the heavier impurities are deposited long before reaching the pond, and little else than the ochered water reaches there, as the gravel and roots are screened out early in the runways through which the flow is made to reach the pond. The sand settles all along its course, or at its first entering into the pond; that which has been held in solution until it reaches the main part of the depositing pond being usually a fair quality of ocher which requires no further washing for ordinary use.

When the pulp has dried sufficiently, teams are set to work with plows and scrapers, and are loaded with the loosened ocher earth and hauled out to the packing sheds, which are roughly constructed affairs, but sufficiently tight to keep the ocher from rain and consequent damage. There it is again pulverized, screened, barreled, and placed either in cars for shipment or in storage warehouses.

This method is by far the cheapest way of handling ocher, but it is limited in that it cannot be made continuous. It is ingenious, and might have been the invention of a Down East Yankee, but that is not so. It is that of a plodding Pennsylvania Dutchman; at least, he was the first one to put the system into use in America, and possibly in the whole world. His works are situated near Allentown, Pennsylvania, and are located in a small valley through which is a runlet which gives the water a chance to reach the larger streams, but which is usually dry except during the heavy spring rains.

Properties and Uses

The statement was made that ochers could be grouped into two general classes, and so they may for the purpose of examining their characteristics and properties.

The two extremes are taken as types, but in reality there are some ochers that are so near the half-way mark between the two types, that it takes a good deal of guessing to tell where they rightly belong. Besides, there are any number of grades from the one type down toward the dividing line forming the line of demarcation of the other. Speaking in a general manner, the bulk of European ochers belongs to the class of ochers containing a silicate base, while those found so far in America are more argillaceous or aluminous in character, and may be so classed.

If the reader bears in mind what was said concerning the silicate white earths under that heading, he will have no trouble to understand why ochers with a silicate base are much better than those having a clay base, at least for the painting of surfaces exposed to the weather. He will also understand why the clay ochers are best adapted to distemper work.

One half of the lamentations which many painters indulge in because of the troubles they have had, caused by the use of ocher, and in the airing of which they at times fill the columns of the trade papers, can be easily traced to the use of the wrong ocher. Investigations will always show that it was an ocher with a clay base that was the disturbing element.

One never hears of troubles from those painters who use the silicate-based ochers under the very same conditions where the other kind is said to have gone wrong, and these can hardly find words good enough to utter the approval they have to give.

Both are truthful in the telling of their experiences, but while each has to tell them from the use of a pigment which has the same name and possibly the same color, each is in reality speaking of something of an entirely different nature and properties.

The troubles had by those who used the clay ochers are of the same nature as those to be expected from the use of china clay, as has been related in the former chapter. Clay ochers when thoroughly dry have parted with the moisture which they originally contained. If a building is primed with such an ocher, it may be called hermetically sealed, especially if the priming was a heavy one, as is usually put on for cheap two-coat work. This heavy priming has practically sealed up the wood and prevented the penetrating of the second or finishing coat, the fine particles of the clay and oil combining to make a poreless glazed surface. The supervening coat put over it dries in much the same way as it would upon a piece of glass; it is not able to anchor itself into the non-porous priming. If the priming had been composed of white lead alone, or of white lead with a reasonable quantity of zinc with it, and put on not too heavy, the priming would have been porous. The finishing coat of lead, or lead and zinc, put over a heavy clay ocher priming, dries upon the surface without clinching itself to it, because it is non-porous. This coat naturally dries thoroughly, having contact with the atmosphere, and becomes porous after the linseed oil has lost its glyceride. The ocher underneath is reached through these pores by the moisture in wet weather, which it will absorb in sufficient quantity to make trouble. During dry, hot weather, this absorbed moisture will be drawn out of it in the form of steam or vapor. Much of it will escape through the same pores by which it entered, but some may not because of a surplus of moisture finding its way to some porous part of the wood, and when the heat is great, the steam not being able to escape as fast as it is formed, forms a blister under the coat or coats applied over the clay ocher priming, and there is trouble. This absorption and evaporation continually

going on tend in time to loosen the superadded coat or coats and to make them part company from the priming, which usually remains intact. This is one of the main causes of complaint made against the use of ocher as a primer.

Silicate ochers have no such effect. Silica does not absorb water. It has no affinity for it, consequently there can never be any of it, either by absorption or otherwise, to escape out of it in the form of steam during warm weather, so that there is no danger of the super-added coats coming off it, as related of the clay ocher. Being more porous, the finishing coat becomes anchored to it, and if it has been properly compounded will remain attached as long as it would upon a lead priming. It is, of course, possible to mix a finishing coat of dope, but such would come off of anything it was applied upon, and this is not a matter for serious consideration.

All kinds of ochers are great absorbents of linseed oil, and should be bought ground in oil rather than in the dry state, unless one possesses good grinding machinery, which is something very unusual.

As may be readily understood, the mere percentage of strength of the colored matter (hydrate ferric oxide) contained in an ocher is not always a criterion whereby to judge of its quality or actual value. The better grades of French ochers seldom contain as much as 25 per cent of ferric oxide, and usually much less than that.

Every painter and decorator is pretty well acquainted with the high character of some of the French ochers, also with some of the English of the Oxford class. These last are considered the best found in England, and justly so.

The following analysis is taken from Church's "Chemistry of Paints," and was made by Professor Church himself from a sample of ocher which was taken from the Shotover

Hill mines near Oxford, and which he says represents fairly the quality of the Oxford ochers:

Hygroscopic moisture	7.1
Combined water	9.0
Ferric oxide	13.2
Alumina	6.3
Silica	61.5
Calcium sulphate	1.4
Undetermined	1.5
	—
	100

The above analysis shows nearly two thirds of the component parts of that ocher to consist of silica, therefore one can pin his faith to it for all kinds of outdoor painting. But note the comparatively small percentage of ferric oxide, the coloring matter.

The French ochers proper are somewhat richer in the proportion of oxide of iron contained in them than that of the sample cited above. Notwithstanding that they average stronger in coloring matter than the Oxford ochers, they are commonly of a lighter and brighter tone. This is remarkable, because ochers which usually contain large proportions of ferric oxide, are darker than those which contain less. It is very hard to account satisfactorily why it is that some samples are so much richer in tone than others of nearly the same chemical composition. Some lack in brilliancy, or, if not in that, are found lame elsewhere. It is therefore useless to look to a chemical analysis for a reason to explain these things.

Some of the better grades of French ochers make beautiful cream and buff tints with white lead or zinc white — so rich in fact as to suggest to one used only to the American ochers that possibly they had been doctored up with chrome yellow. This richness is inherent,

and the tints made from them will never fade, as would those from a *chromed* ocher.

It is customary with many color grinders to tone up ochers with chrome yellow. When this is done, and sold under the proper name, and labeled as a "Chrome Ocher," it is all right. That is a legitimate transaction; but when this is done to tone up a poor ocher so that it will sell better, then it is all wrong, and is bound to work an injury upon the unwary users of it.

If such ochers are used for solid painting, the chrome yellow will fade away, leaving the ocher its original ugly color. If such an ocher has been used in making tints, the rich tone will disappear even more quickly.

The painter using these may possibly have saved a quarter of a dollar in the difference of cost between a good French ocher and what he used in the making up of his tint if the house was a good-sized one, but in reputation the loss cannot be computed in quarter dollars. Had he used the right ocher, the gain would have been permanent; the customer would have been better satisfied, even if he knew little about color. Every neighbor seeing the house holding its color so well and so long would have become a free "ad" for the painter. The wishy-washy, fady, spotty-looking house is another kind of an "ad" loudly proclaiming that the man who did the job did not know his business.

Page after page of ocher analyses might be given, but would only confuse the mind. All they do or would prove is that there is no such thing as uniformity to be found in them, and this has been said so often here that it is unnecessary to prove it again by crowding in useless testimony.

The reader has been advised to buy his ocher ground in oil. There are good reasons for it. Manufacturers

of reputation are much more careful buyers than the average painter can be. They know how and where to buy pure French ochers. They have men in their employ who are experts in this line. They can buy direct from the importers, if it be so that they do not import it themselves, and will receive it in the original packages from the custom house as imported. The painter who thinks he can tell unerringly a French ocher when he sees it, or who depends upon the stenciled marks on the barrels bought from his supply houses or the jobbers, will in nine cases out of ten be imposed upon. Besides, the best reason of all is, that allowing he can buy just the same as the manufacturer, he certainly cannot afford to grind it. The grinding of a good ocher should never be done in an iron mill, as, when it is so ground, it is likely to lose brilliancy, or at least impair some richness. Stone mills are the only ones fit for grinding ocher, or, for that matter, all other colors, including the blacks, if brightness of the color is of any object — and it surely ought to be. The above is said for the benefit of the painter who is thinking about the buying of a paint mill so he can buy his colors dry and pure (?), and save his hard-earned dollars instead of giving them away for colors ready ground. The man who owns a collection of paint mills, and has them rusting away down in the back part of the cellar, *knows better*, and the advice given does not concern him.. All the money that a painter has ever saved by the grinding of his own colors can be put inside of a very small pocket book, and in old-fashioned copper cent cart-wheels at that.

Grinding colors so that they retain their brilliancy of tone, and are ground to the last degree of fineness, is a science and trade by itself. The painter can never learn it thoroughly, nor can he equip himself rightly for it except

at too great an expense for it ever to pay him to do so. There is quite a capital tied up in such an equipment, which in an ordinary shop will be required to work for possibly one week out of the fifty-two in the year. This machinery will have to lie idle fifty-one weeks yearly. There will be nothing for it to do. If he intends to keep it going so as to sell to others, all right and good — but then the painter will find it more profitable to give up the painting business, as he cannot expect to make a success of both at the same time.

There are few shops, aside from those of large railway systems, where the grinding of colors has ever been done advantageously. In these there is a set of men whose sole business it is to attend to the grinding, and who, if they are not expert grinders at the beginning, soon become skilled by keeping constantly at it. Even in these large shops there is no economy claimed by the master mechanics. The cost of installing and maintaining the grinding plant, and the wages of the employees detailed to that work, more than eat up the difference in cost between the dry pigments and the ground goods prepared ready for thinners, bought in large quantities, as these shops do.

The large capital invested in expensive machinery which is constantly needing repairs soon disgusts the most enthusiastic, and, like all dearly bought experience, it comes to stay with them. Hence the discarded machinery in the cellar, or that which goes to the scrap-iron heap.

This lengthy advice and warning is given here, not so much because it appertains to ochre more than to any of the other colors, but because ochers being the first ones of the colored pigments under consideration, it seemed best to give it under that head, and it will not have to be repeated again. Such advice and warning is needed, and if followed it will save dollars to the man heeding it.

During a lifetime, the author has visited in one capacity or another for nearly fifty years several thousand paint shops. In a very few he has seen mills set up; in many more he has seen the self-same mills relegated to some out-of-the-way place. In all instances where the owners were asked about the saving effected by their use, the reply has been — *nothing*.

Upon returning after a year's absence to shops where they had been set up, they had disappeared, and the same answer was received as the reason for their removal.

As nearly all the characteristics presented so far appertain mainly to the class of ocher known as the "silicate" or the French and English, more will be said now of the special characteristics which belong to the other or argillaceous class — those where the clay base predominates.

Reasons have been given why the silicate ochers were the best for outside painting, and why they should be used for that purpose to the exclusion of the clay ochers. But for distemper or water-color work the French and English ochers are not nearly as well adapted as the American clay ochers.

Most people are better acquainted with them under the name of American ocher than any other. In the markets, the division of ochers into the silicate or clay classes is unknown. The French and English or the American in various grades is all the classification they receive. To all intents and purposes it really amounts to the same, as the imported represents the silicate class, and the American the clay class, because about all found so far in America partake more or less of this character.

In distemper painting, clay ochers work better. They cover better, and, what is still more prized, they look better than the silicate class does; so that what they lack for oil

painting becomes their chief redeeming quality in water-color work.

This class of ocher is very common. It is found in nearly all if not in every state in the Union. Like the other ochers, it varies very much in composition. So far, the best that have been found are mined in Eastern Virginia on the Appomattox River below Petersburg, and in the same section at Bermuda Hundreds.

Those Eastern Virginia ochers contain a fair percentage of silica in their base, but the alumina predominates. They carry about 25 per cent of ferric oxide. Their tone is fair, and they may be said to be the nearest approach to the imported — many jobbers sell them as "Rochelle." These represent the better grade of American ochers found so far.

On the other extreme — in Missouri down on the Iron Mountain railroad below St. Louis — there are found numerous beds of ocher. The remarkable peculiarity of these ochers is the enormous quantity of ferric oxide they carry. Some samples analyze as much as 85 per cent ranging down to 20 per cent. A fair average for that section will be more than double that of the imported class. But what the oxide of iron makes up in quantity it seems to lose in quality, the tone being universally poor.

Their chief use so far has been found in the burning of them into a red ocher and in compounding them with talc in the making of a cheap Venetian red or rather mortar color for which they are excellent, being so strong. Enormous quantities are sold for that purpose alone.

Some of these very strong American ochers are also compounded with ground talc, gypsum or silicate earths; some being sold as French and English, but the bulk going under the American name.

Most of the American ochers are semi-transparent, and but for their tones could be classed with perfect propriety with the siennas. Some which do come nearest to them are so classed and sold as American siennas. This transparency is not apparent in distemper painting, but it becomes decidedly objectionable for oil painting, even when compounded with silicate earths, and thus rendered unobjectionable in all other respects.

In addition to the natural ochers, tons upon tons of that pigment are made artificially. When a good quality of ferric oxide is used as the coloring agent, and a right base selected to hold it up just right, the product can hardly help being a good one. There surely cannot be any good reasons given why an excellent artificial ocher should not be made as well as an artificial Venetian red, which these all are. What is said under the heading of that pigment regarding preparation will give the reader an idea of how these artificial earths are produced and prepared for use. There is this difference, however, that in the case of ochers no calcination is necessary — all that is needed is mixing and triturating. The base is usually either china, clay, talc and silicate earth in such proportions as best suit the compounders.

The great trouble heretofore has been in the finding of an hydrate-ferric oxide of sufficient richness to compete with the French and English imported ochers. So far, all these artificial ochers have had a lame side in that they are all too transparent in oil to be palmed off as genuine French ocher upon the expert ones at least.

For all that, the French and English ochers are silicious; they are very opaque, much more so than any sample of American containing twice the quantity of coloring matter. It looks as if the atomic formation of the hydrate-ferric oxide from over the water was somehow different from

that produced on this side of the big pond — or is this due to the forms of atoms in some of the bases? There seems to be an opening here for scientists to investigate.

This kind of transparent ferric oxide appears to be found in Italy, as many of the Italian siennas contain twice as much as many of the French ochers, and yet they are very transparent for all that.

As soon as the proper hydrate-ferric oxide can be found or artificially produced with as good tone as that in the imported ochers and as opaque, so that they can be duplicated at will here, there will be as little French and English ochers imported as there is now of English Venetian red. In all likelihood it is only a question of time when this will take place. All signs point that way now, and the painter will gladly hail the day when he can depend to a nicety upon the uniformity and exact composition of his ochers.

Some of these artificial ochers that have been very carefully compounded, can be relied upon as being very superior for outside painting to those that are mined and that are of uncertain composition. Samples which were examined and tested show up nearly as good as many that are imported.

As ocher is the most important of all the colored earth pigments to the painter, no apology is needed for having given so much space to its consideration.

CHAPTER VI

CHROME YELLOW

YELLOW PIGMENTS (*Continued*)

General Remarks Concerning Them.

THE chrome yellows follow the ochers in the list of yellow pigments, and rank next to them in usefulness and importance to the painter.

These yellows are all chemically made in color works, and are found of various tones covering the whole range, from a deep orange bordering upon a true red to the lightest of the canary yellows.

Commercially they are known as "canary yellow," which is the palest; "lemon yellow" comes next to that in paleness; "medium chrome yellow" is the neutral chromate of lead, and its shade borders neither towards the orange nor the lemon. It is neutral in this respect as well as chemically. "Orange chrome yellow" runs in a variety of shades from a very pale tinge of that color to a deep — almost scarlet — shade of it. Some manufacturers make it up in three shades, which they mark as "pale orange," "orange," and "deep orange."

The medium chrome yellow is the only one of the whole range that is the true "chromate of lead." The variations from it are due to the addition of other substances added purposely to produce them. So the medium or neutral chromate of lead, is the base, or standard, from

which all the others are mere variations. For this reason its character will be the first one considered.

MEDIUM CHROME YELLOW

Its Characteristics, Chemistry, and Manufacture

Chrome yellow has been known under various names for over a century. As its name indicates, it is derived from chromic acid and a lead base.

It is easily obtained as a precipitate by simply making solutions of the acetate or of the nitrate of lead, which are soluble in water, and of bichromate of potash, and pouring the two solutions together in a settling tank. The chrome yellow will instantly precipitate.

Color manufacturers, however, make it from white lead, as it is more economical to produce in that way. This being insoluble in water, requires more manipulations and boiling. The proportions used are about four pounds of white lead to one of the bichromate of potash.

CANARY AND LEMON CHROME YELLOW

Manufacture

The lighter shades of chrome yellow are made in precisely the same manner as the neutral chromate of lead or medium chrome yellow, with this difference: lead sulphate or sulphuric acid must be added to the white lead and bichromate of potash. According, therefore, to the quantity of the sulphate of lead added, will be the canary, lemon, or intermediate light shades. The more sulphate of lead that goes in the mixing liquids, the lighter will be the shade; the less of it used, the nearer will it approach to that of the medium chrome yellow.

Sulphate of lead is a legitimate component part of a pale chrome yellow, however much of an adulterant it

may be when added to an already made and precipitated medium chrome yellow or an orange shade where it has no business to be, and where, if found, it is a sure indication of adulteration.

The sulphate of lead must be added before the precipitation of the solutions so as to produce the lighter shades, as it combines with them then, which it will not do if added afterward.

Sulphate of lead is frequently used as an adulterant of medium chrome yellow by simply mixing the two by trituration. In such a mixture the color of the medium yellow is not changed.

Chemists who are not familiar with this fact, and who have not made the study of paint-making a specialty, frequently make queer mistakes in their analysis. They know that chrome yellow is neutral chromate of lead, so that when the lighter samples of chrome yellow are handed to them for analysis they are sure to call the sulphate of lead they are bound to find in it an adulterant, not knowing enough about color-making to make the proper allowance for the difference in the shade between that and the medium. It is only when found in a medium chrome yellow, where it has no business to be, that it can be considered an adulterant.

As these light shades of chrome yellow vary so much, it is impossible to give the exact amount of sulphate of lead they should contain.

Alum and barytes are sometimes used to lighten the tones, but principally as adulterants.

ORANGE CHROME YELLOW

Manufacture

Orange chrome yellows are the opposite of the lemons. It has been shown that in the lemon and canary chrome

yellows, the change of tone from that of the medium was due to the addition of an excess of acid in the form of sulphate of lead or sulphuric acid.

In the orange chrome yellows, the deepening of tone and reddish hue is due to an excess of alkali from the use of some caustic substance. It may be obtained in many different ways, but, after all, the difference is in the caustic substance added to the white lead and bichromate of potash. As stated under the lemon yellows, they must be added to the chromate of lead, or rather to the solutions of chemicals which are equivalent thereto, and the whole precipitated together. The alkaline substances mainly employed for this purpose are caustic soda or caustic potash. The greater the quantity of these used, the redder will be the tone of the orange chrome yellow.

In an analysis of orange chrome yellow there will be found, besides chromate of lead, either lime, soda, or potash, according to which of those substances was used before the striking of the precipitate. Therefore, according to the quantities of the alkali, the various hues and shades of orange are produced from the faintest tinge of orange to those of near approach to a fiery red. There can be no formula given of the proper amount to use for the producing of any given shade. The manufacturers hardly ever strike duplicates of any shade, but produce hundreds which are not alike. They do grade and mix many together which will give a fair average for the standard they have adopted for the required shades of it.

Properties and Uses of Chrome Yellow

Chrome yellows of all shades and hues have about the same general characteristics and properties, qualities and defects. It is proper, therefore, to bunch them together,

and to review them under the general head which is the common property of all.

From their composition, one may well surmise that they are hardly fit to be used in distemper or water-color painting owing to the liability of their chromic constituents of losing their oxygen and of thus becoming changed into the lower oxide of chromium, which is *greenish*. The lead also is subject to the attacks of sulphureted-hydrogen gases which turn it into a black sulphide. It must be easily seen by any one that great risks are run when they are used in water colors for interiors, about the only place where water colors can be used. When used in oil, they are protected to some extent by the linseed oil with which they are mixed, but in water colors there is no protection whatever against deleterious attacks.

In oil, however, there are but few colors which the painter or decorator could find more useful than the *chrome yellows*. While not absolutely unfading when mixed with oil or varnish, in those vehicles the color remains a reasonably long time before changing to such a degree as to be disagreeably noticeable.

The range of tints obtainable from them covers the whole field of yellows and red yellows, which are easily made and at a very moderate cost.

There is one thing that is sure: There is nothing in the whole field of pigment that would replace them, let them be good or bad. It is true that some very few tones could be made from combinations of other pigments, but at a greatly increased cost only, almost prohibitive for general house painting, and nearly all these substitutes would be much more subject to fading than the chrome yellow itself. With all their defects,— and it is admitted that they have many,— they stand high above every other pigment producing the same range of color. They will continue to be

used until something better is discovered to replace them.

There are many fancily named yellow colors upon the market, usually with a proprietary name. They are mainly prepared for the carriage trade. Most of them are chrome yellows of peculiar shades.

The fancy names sometimes mislead the uninitiated into the belief that they are not chrome yellows. This belief is dangerous, as it may lead one into using those yellows upon work where chrome yellow should not be employed, the workman thinking that they are not subject to the same vicissitudes. With a knowledge of their real character, such mistakes need not occur.

Chrome yellows are extensively used for all kinds of painting. The carriage, car, and implement trades use them in enormous quantities as well as the house painter.

Decorators and artists are the ones who are the most likely to have trouble with them. They are the only ones who need have any misgivings regarding their use. They know that even when mixed with oil, the chrome yellows are not to be depended upon for use in interior work. They are therefore warned to be shy of them, substituting other yellows as far as they can.

BARYTA LEMON YELLOW

Properties and Uses

This is a distinct color from lemon chrome yellow. It contains no lead in its composition, baryta being the base of it. It is by far the most permanent form of that color.

It is made by mixing solutions of neutral potassium chromate and of barium chlorite; both solutions having previously been heated to 100° C. It precipitates as all

others made by mixing solutions having an affinity for each other.

Unlike the lead chromates, it does not blacken by contact with sulphureted-hydrogen gases, that lurking enemy of interiors. It may also be mixed with impunity with any of the other permanent pigments.

This yellow is of great use to decorators and artists, more so to them than to the general house or carriage painter, because it has not so much opacity in oil as the chrome yellows, on account of the transparency of its base.

It possesses one of the defects which is also common to the chromates of lead. It loses some of its chromic oxide and becomes greenish in hue.

Adulteration in Chrome Yellows

To detect adulteration in chrome yellow is an easy thing. It can be done by a very simple operation, which while it is not a scientific one, and while it gives no indication of the nature of the adulterant, is nevertheless very effective. By its use, any one can readily determine for himself whether a given sample of chrome yellow is pure or not. This, after all, is all that either a painter or a dealer cares to know about a color anyway. The test gives approximately the percentage of adulterant contained in the color under examination. Its lameness is that the nature of the adulterant is not revealed. That requires a chemical analysis. As this test is applicable to many other pigments, especially to all made from chemicals and which possess a recognized standard of purity and composition, and as it is also, in part at least, applicable to many of the earth colors in so far as it will frequently help one in determining the value of these, the manner of making this test is minutely described, so that

hereafter, when there may be occasions for reference to be made to it, the reader can turn back to the explanation given here, should he require to have his memory freshened up as to the "modus operandi" of making the test.

The Scale Test for Adulterants in Colors

As a detector for adulteration in colors, the test which is about to be described is applicable in full only to those manufactured in color works from well-known formulas, and which, if pure, should contain a known amount of coloring matter. That is what gives them their commercial value. This test only becomes a side issue with colors whose chief value consists in their fine tone and their brilliancy, as with most of the earth colors. Even with these, the test will serve to determine which is the more valuable between two samples of equal tone and brilliancy in determining that containing the greatest quantity of coloring matter.

Every one interested in colors, be he dealer or painter, should possess a pair of fine scales for testing. These should be very sensitive ones, very accurate, and able to weigh with precision as small a portion as a quarter of a grain, or at least a centigram. Such scales need not necessarily be expensive. The knocked-down army surgeon pocket scale is good enough, if one does not care for style. That has a little flat box with a drawer fitting inside. This box serves as a pedestal, and the drawer as a receptacle into which is packed away the standard that screws into the pedestal and across which the arm of the scale is pivoted and supports the two platters, pans, or balances which receive the substances to be weighed. They can be put up and taken apart in two minutes, and will answer every purpose.

The testing in substance is done in the following manner. Two samples of a given color are procured — one of which is of known purity, to serve as the standard in judging the others. A very good plan is to take tubes of, say, Windsor and Newton's artists' colors, or any other make whose purity is as well established. The above firm's make is named because they are universally known and acknowledged as standard in both quality and purity. A sample tube of all the principal colors should be found upon the shelf of every paint shop and of every paint dealer. The cost is very moderate.

It stands to reason, that if a person should take, say, one pound of color ground in oil, and add thereto twenty-five or fifty pounds of white lead, and that after triturating them properly they will make a tint that should be equal in strength or depth of tone and in its quality to any other sample or samples tested with it if those samples have been weighed out and treated in exactly the same way, they will do so if they are pure and unadulterated. If, on the other hand, some of the samples do not give as deep a tint as the standard color, it follows necessarily that there must be deficiency in coloring matter.

It is impossible to determine to a fraction the amount of adulteration contained in the weaker pigment, but one can make a very close guess of it in this way:

Add enough white lead to the sample which is the strongest in coloring matter so that its tint will be reduced to the same shade as that of the weakest; then reweigh and note the variation. Thus, if one pound of a certain pigment tints twenty-five pounds of white lead to a given shade, and in the other, the one pound of the same color has been able to tint thirty-seven and a half pounds of the white lead to the same shade as the other

has — then the first must have been adulterated with 50 per cent of *something* that was not coloring matter. If, instead of thirty-seven and a half pounds, it had been able to tint fifty pounds of white lead to that same tint, then the adulterant put into the color would be equal to 100 per cent. In other words, the sample contains one half pound of true color and one half pound of adulterating material, so that for tinting purposes it is only worth one half as much as the stronger one.

Some may think that the above is an extravagant statement to make, even as an illustration to show how the test works, but it will be found very much below the truth. This is especially so in the higher-priced pigments and in those possessing great strength of coloring matter.

In making tests, there is no need of using any such quantity of color and lead as was stated in the illustration. One grain in weight is as good as one pound, or even better. No weights need be used, as a bit of coloring matter the size of a pea can be put upon one of the platters, while another bit of color can be placed upon the other, and added to or subtracted from until they balance evenly. Each of the colors to be tested should be put upon a little piece of paraffined paper about a square inch in area. That paper will not absorb any of the color or oil, which can be wiped clean off of it. For accurate testing, it is better to weigh the colors separately in centigrams or grains. Next proceed to equal quantities of white lead of same consistency, placing that also upon squares of paraffined paper, but larger than recommended for colors, so as to accommodate the larger bulk of the lead. These are placed upon the platters and balanced in the same manner as for the colors by either adding

or subtracting; or, if perfect accuracy is desired, weigh out twenty-five or fifty grain packages of white lead, one each for each color being tested.

Have several pieces of glass ready which have been properly cleaned, and upon one of these place the first sample, which should be the standard color. Add to this one of the packages of white lead previously weighed out. Triturate the color with the lead until the tint is uniform all through, using a palette knife for that purpose; add a given number of drops of oil if needed to help the mixing, then set it aside.

Proceed to treat the next sample in precisely the same way, and stand that aside too. If more than two samples are being tested, keep on treating each in the manner described.

Now compare each sample with the tint made by the standard color and note the differences. If each shows about the same strength in their tints, well and good; the colors are pure. If, on the other hand, one or more do not come up to the tint of the standard, there is something wrong with them. By adding enough white lead to the standard tint to bring it down to the tint of the next strongest sample being tested, and weighing each, the difference between them will give the quantity of adulteration contained in the sample.

If more samples than one are being tested at the same time, proceed to add more white lead to the standard color; continue adding white lead to the standard to bring it down to the tint of the next sample in strength, weighing each time and noting the difference, and continue doing so in like manner until the standard has been reduced to the tint of the last or weakest in the lot. This will give the relative value that each bears to that of the standard used.

Thus if the standard color is capable of producing a tint from one grain of color added to two hundred grains of white lead equal to that which sample 1 does from one grain of color to one hundred grains of white lead, and as sample 2 does with fifty grains of lead, then if the standard color can be bought for twenty cents per pound, sample 1 is worth, proportionately, ten cents. Sample 2 is only worth five cents per pound, because No. 1 contains only fifty per cent of the coloring matter as compared to the standard, while No. 2 carries only twenty-five per cent of it.

In the testing of chrome yellows, samples of different tones should never be tested together,—for instance, a very light lemon yellow against a very dark one, or a lemon chrome against a medium or an orange chrome, or vice versa. The tints made will be so much different that it would be very hard if not impossible to judge the results correctly when placed side by side.

This test usually brings out other valuable points, *i.e.*, the quality of the tints made from two or more given samples. A medium chrome yellow may be nearly *pure*, but it may be very *poor*. Therefore, if the tint obtained from it is muddy, and that from the standard is bright, clear, and pure-toned, it follows that the muddy sample was a badly made chrome yellow, and that, notwithstanding its purity, it may possibly be of less value than one which has been adulterated but which is of good tone and well made. This is a test of quality which is brought out incidentally by the use of the scale test.

The testing of the quality of colors does not require the scale test, however, as one can ascertain that by the eye alone. All that is required is to mix some of the color with white lead to make a light tint of it. The tint will speak for itself. The tone of some samples of chrome

yellow may be so poor that the quality can be determined without disturbing it or even taking it out of the can. As occasionally it may belie its looks, it is safer to add some white lead. Then there can be no doubts left in one's mind.

Color tests made in the above manner are very simple and convincing; and the painters or dealers who make a start in testing the material they use or sell, hardly ever quit making a regular use of it, thereby gaining an experience in judging of colors and their values that will be very profitable to them in after life.

CHAPTER VII

YELLOW PIGMENTS (*Continued*)

GAMBOGE

Properties and Uses

GAMBOGE is seldom if ever employed by the house painter, but is still used by a few decorators and artists. Its chief value is as a glazing color; in reality it cannot be used for any other purpose; some few carriage painters who do fancy colored painting use it to obtain certain effects.

Gamboge is of vegetable origin; being a gum-resin. It should never be mixed with other pigments containing lime or alkali in any form; they would surely darken.

It cannot be safely used as a distemper color, as it fades rapidly upon exposure to the air and the sun's rays. Its use even in oil is questionable, but it is fairly permanent when well protected by varnish.

Its chief use to artists is in the peculiar shades of green combined with indigo or Prussian blue.

The paint world is likely to keep moving on a long time after it has been discarded, as its place can be advantageously taken by Indian yellow or aureolin.

AUREOLIN, OR COBALT YELLOW

Properties and Uses

This is another yellow pigment which will hardly ever trouble the ordinary house painter. A few decorators use

it sparingly. It is used principally by artists in water-color work. It is transparent and rich-toned, and is superior to gamboge for glazing purposes.

It is a non-drying color in oil. When prepared for use in that vehicle it will prove more or less troublesome. If it can ever be prepared in such a way as to make it part with its water of hydration,—in other words, rendered anhydrous at a reasonable cost,—it may then become a very popular color not only among decorators but for carriage and the allied trades as well as for any other kind of painting. As it is *now* in its hydrated state, it soon loses its rich tone and assumes a dirty appearance. Hydrochloric and nitric acids do not seem to affect it to any extent, but ammoniacum sulphide destroys its color at once, and sulphureted hydrogen gases soon darken it.

The future may give us the anhydrous aureolin at a reasonable cost. When this is accomplished, it will be a great addition to the list of yellow pigments. In that form, it dries readily when mixed with a siccative oil, and that is the form in which artists now use it for oil painting. As they use it in small quantities, it does not make such a big hole in their bank account as it would were they to use it in quantities as the house painter or decorator would.

INDIAN YELLOW

Properties and Uses

This pigment is of animal derivation, but in reality it is of vegetable origin obtained through animal agency; it is found in their urine. In Bengal, cows are fed upon mango leaves, and the urine of cows so fed becomes impregnated with the coloring matter which forms Indian yellow.

Church says of it: "It generally occurs in the bazars of the Punjab in the form of large balls having an offensive, urinous odor." Indian yellow is an impure salt of (magnesium) euxanthic acid. The essential part of it is a compound containing 4.5 per cent magnesia, 18.7 per cent water, 78.7 per cent euxanthic anhydride; but this substance is always associated with various impurities both mineral and organic, even in the most carefully purified samples of prepared Indian yellow. The pure magnesium euxanthate is represented by the formula $C_{19} H_{16} MgO_{11} 5H_2O$.

"For artistic purposes the crude imported Indian yellow is thoroughly powdered, and then washed with boiling water until the liquid filtered from it is no longer colored; a brown impurity and much of the evil smell are thus removed. The color of the washed product is enriched by leaving it in contact for a day or two with a saturated solution of sal ammoniac and then repeating the treatment with hot water. Thus prepared and purified, the pigment presents a translucent orange yellow of great depth and beauty. Ground in oil, some specimens remain practically unchanged even after long exposure to sunlight, any darkening which they show being due to either imperfect purification or to change in the associated oil. Such change is reduced to the minimum if poppy-seed oil is substituted for linseed oil, or if the latter be previously treated with manganese borate."

As a water color, Indian yellow is also very useful. It is not absolutely permanent, but fairly so for a water-color yellow. Its fading, being very slow and gradual, is not noticed readily.

It can be mixed with any of the permanent pigments, and sulphurous compounds do not affect it injuriously. It is too expensive a pigment to ever become extensively

used by ordinary painters, but it deserves to be more than it is by decorators, scenic painters and artists, also by the carriage trade as a glazing color. It does all that gamboge is expected to do for that purpose, and much more in that it remains permanently.

NAPLES YELLOW

History and Chemistry

The early history of this pigment is very obscure. It was first brought to notice in a commercial way by the Italians, and imported from the city of Naples in Italy into England, and it was named after the city of its exportation by the English importers. The Italians themselves know it as *yellow* or *gialloline*. It is a compound of oxide of lead, antimony and zinc. Twelve parts of the *metallic* antimony are calcined in a reverberatory furnace with eight parts of red lead and four parts of the zinc. These mixed oxides after being well rubbed together are fused, and the mass broken into a fine powder.

The hue is rich, fresh, and brilliant. There is a considerable quantity of this yellow placed upon the market that is made simply by mixing cadmium yellow or a deep cadmium with the white oxide of zinc. This, while it makes a good imitation of Naples yellow, is not *it*, for all that it may look like it.

While it is only of comparatively recent date that it has come back to us, the first notes of its appearance only dating back to the middle of the sixteenth century, it was known to the ancients for many centuries previous to that time. It was used in the enameling of brick in Babylon 700 years B.C., and the Persians used it also in the enameling of their pottery.

It has been used extensively by artists, decorators, sign and carriage painters, and is still used to a certain extent by some of all these to-day, but not nearly to the same extent as it was fifty years ago. The chrome yellows have made quite an inroad upon its use, and have displaced Naples yellow in many shops.

Properties and Uses

Naples yellow is fairly permanent, but, like all compounds containing lead, it is blackened by sulphureted-hydrogen gases. It is also darkened by contact with iron, zinc, pewter, tin, and many more metals, to the extent that even an iron palette knife should never be used in triturating it, but a bone one should always be employed for this purpose.

Naples yellow should never be used in combination with certain organic pigments as cochineal, the various yellow lakes, indigo, etc. Naples yellow is worthless as a water color, as it is very fugitive when left unprotected by the enamel formed by the drying of linseed oil or varnishes.

It is gradually becoming displaced by the chrome yellows and ochers, or combinations of these two, and with no serious loss. The Naples yellow tone can be readily imitated; and in this one instance at least the imitation is superior to the original, — it is more permanent.

DUTCH PINK

Character and Preparation

Dutch pink has many synonyms, *i.e.*, yellow lake, Italian lake, quercitron lake, brown lake, yellow madder, and a host of others under which it is known in various sections, especially in England, where it is

unknown under the American cognomen of Dutch pink. As under this name only is this pigment listed in pigment catalogues in the United States, and as this is recognized by all color makers in their price lists, the name is used here in preference to any of the synonyms. Why it should be called a pink (?) when it is not a pink, but a yellow, is one of the conundrums that must be passed around to some one else for a satisfactory explanation.

Dutch pink is of vegetable origin, and it can be and has been prepared from various sources, but it is now chiefly derived from quercitron, a product extracted from oak bark. Our black and red oaks contain the greatest percentage of it, although it can be obtained from the bark of white oak also.

A decoction of the bark is made by boiling, and the quercitron is precipitated by pouring into it while hot a solution of alum and dilute ammonia.

A richer-toned pigment is produced by using dilute boiling sulphuric acid instead of water in extracting it either from the ground bark or alburnum.

In former days much of the Dutch pink was obtained from various species of buckthorn and of the Rhamus family of shrubs.

Properties and Uses

It is possible that the variety of names under which Dutch pink is known may have been given to the various extracts at some time or other to note some slight variation of tone in them. This is more than doubtful, as it is next to impossible to ever find any two lots of it that are just alike in this respect. It is useless to keep up a confusing nomenclature, and all lakes of the same extraction should be classed together and known by one name.

only. When an Englishman calls for any of the above-named lakes, the dealer will be perfectly safe in giving him Dutch pink instead of them.

Dutch pink has but little permanency when used in distemper for wall coloring, and yet, strange to say, that is the purpose for which it is mostly used. Why that is so is one of the unsolvable mysteries.

Its use in the United States is confined to a few sections where the traditions of its usage have been handed down and inherited without the worth of the legacy having been investigated.

In oil it is a bad drier, and while it is more permanent in that vehicle than in distemper,—because of the preserving influence exerted upon it by the linseed oil,—it is insufficiently so, and there is no need of one taking unnecessary risks by using it. As a glazing color it is all right while it lasts, and it is used for that purpose in some carriage shops.

CADMIUM YELLOW

Chemistry, Properties, and Uses

This pigment is chiefly useful to the artist and to the decorator. When properly prepared it is fairly permanent, but as its cost is relatively high and must ever remain so, for this reason if for no other its use will never become popular with the house painter. As its name indicates, it is a product of the metal cadmium, a near relative of zinc. It is a sulphide of cadmium. The process required for its manufacture and preparation is too intricate and too lengthy to relate in a treatise of this kind, however instructive it might be. Its use is too limited to warrant giving it the necessary space. It runs from a yellow with a slight orange streak in it to

all the intervening shades from the lightest to the deepest orange.

It possesses some very good traits. One is that of preventing the injurious action of sulphureted-hydrogen gases upon white lead when it is mixed with that.

On the contrary, again, such colors as Paris green are ruined by contact with it, and so are all others which are incompatible with a sulphide.

The cadmium yellows work well in either oil or distemper, and make beautiful tints with white lead. Some of these shades resemble true Naples yellow, and as they are more permanent, they are often substituted for it. When cadmium yellow is used in oil, this should be made siccative by the addition of driers.

It is, therefore, chiefly used by decorators for interior work. This is more liable to attacks of sulphureted-hydrogen gases than outside painting, and as the chrome yellows are badly affected by them, and therefore unsafe to use, cadmium yellow's chief utility is to replace them under these conditions.

KING'S YELLOW (ORPIMENT)

Chemistry and Characteristics

This pigment is the yellow arsenic sulphide, and on account of its poisonous character should be discarded.

The only excuse for listing it at all is that, under its heading, a note of warning might be given against its use. It is listed in some of the artists' goods catalogues, and some reference is made to it in some of the past paint literature.

Under its best aspects it has little to recommend it, and when its poisonous character is taken into account, no one need have anything to do with it. At best, it is

quickly destroyed by light, and while it possesses a beautiful hue, that fades away so quickly as to render it worthless.

It was used rather extensively at one time, especially in the latter part of the eighteenth century and at the beginning of the nineteenth. It has all disappeared from the paintings of that period which have been preserved, and it is but seldom used to-day even by artists.

The above ends the list of yellow pigments. It is true a few others are sometimes found listed in artists' catalogues, such as Mars yellow, etc., but a close inquiry will develop that they are simply ochers or compounds of colors which have been described.

The endeavor should be made to keep the list of pigments to the least possible number and to simplify the nomenclature by eliminating from the list all pigments of the same nature sold under various names, thus creating a false impression in the minds of many that they may have different properties.

Many of the yellows which have received a description in this treatise will be found of little benefit to the general painter, but most are of use in certain special kinds of work which are named. The very knowledge that they are not adapted to his work is of value, as it may save him money in the making of useless experiments. The aim has been to give warning of all the defects as freely as the giving of praise to the good qualities of each when that was really deserved.

CHAPTER VIII

RED PIGMENTS

VERMILION

History and Provenance

QUICKSILVER VERMILION is usually understood when the word *vermilion* pure and simple is used alone. All others have some descriptive name added to indicate their character.

Quicksilver vermillion is commonly listed as *English Vermilion*, and the name has come to have that significance to the paint trade of the United States.

Vermilion is found as a natural product in the shape of and under the name of *cinnabar* in various parts of the world. It is most abundant in China, and has been found and used in that country from time immemorial. In America it is also found plentifully in the New Almaden mines of California. In Spain, in the old Almaden; in short, wherever quicksilver is mined, there it is usually found.

It is frequently obtained in masses which vary very much in color, ranging from a light crimson through the scarlet red range of shades to a dark slate gray. These masses after having been powdered become scarlets or reds of various hues.

The native vermillion or cinnabar is usually singularly pure and free from foreign matter, and the impurities seldom amount to as much as one per cent of its weight. It is friable, readily pulverized.

Chemistry and Manufacture

Cinnabar is a native sulphuret of mercury, and it is composed of 86 parts of mercury united to 14 parts of sulphur.

It is most probable that it was used at very remote periods in such decorations and art as then existed. Theophrastus names two varieties of cinnabar as being known to the Greeks. Pliny and Vitruvius also mention it in their writings.

Vermilion can be made artificially by following the formula nature has adopted to produce the native cinnabar. The vermillion of commerce is nearly all made artificially.

The process of manufacturing it, while it may be called a very simple one, becomes rather complex before the end is reached.

The combination of quicksilver and sulphur is readily accomplished, it is true, but the result is a black mass known as *Ethiops*. This is the black sulphuret, and it is identical in chemical composition to the red, with this difference — that the black is amorphous, while the red is crystalline.

There are two processes of manufacturing vermillion artificially: one is known as the *dry*, and the other as the *wet*.

In the dry method of manufacturing it, the mercury and sulphur in the proportion of 21 parts of the former to 4 of the latter are agitated and mixed in a revolving cylinder. The resulting black ethiops is then submitted to a process of sublimation in vertical cylinders, over which are placed connecting receivers. Upon being heated sufficiently, the sulphuret of mercury sublimes as cinnabar near the retort's heads; the finer quality is

found the farthest away, and the poorest the nearest, as that contains a quantity of free sulphur. It is afterward separated into various grades.

The vermilion is mixed with water to a stiff paste, and thinned with a solution of caustic potash and nitric acid, and thoroughly washed with boiling water. There are other processes of manufacturing vermilion, but they differ but little in their essentials from the above, and therefore will not be discussed. All have the same object, — the conversion of the black amorphous sulphuret into the red crystalline form by sublimation. Some add one per cent of sulphide of antimony with a view of enhancing the beauty of the product.

By the *wet* method, the processes are much simpler, and there are a number of different ones in use. The simplest is that of Buchholz: Take four parts of mercury and one part of sulphur, which are digested together in six parts of water. Potash is added as required. The longer the heat is continued, the stronger and more carmine will be the product. When the desired color has been produced, the vermilion is thrown into a vessel of water and washed until all the sulphuret of potash has been removed. The color of vermilion is not changed when moistened with nitric acid.

Carmine is sometimes added to the crimson varieties of vermilion to enhance the tone. The Chinese vermilions are usually of that shade. They are frequently adulterated with carmine. It can easily be detected by putting a small pinch of it upon a piece of blotting paper and wetting that with a few drops of strong aqua ammonia. If adulterated, a crimson stain will appear upon the paper; otherwise it will not be affected.

Vermilion that is prepared from the native cinnabar is said to be more permanent than that which is made

artificially, but one should not adopt the statement implicitly.

Characteristics and Uses

When vermillion is used under proper conditions it is fairly permanent, otherwise it is not.

As to the darkening of vermillion, the common complaint made against it, one must bear in mind that the *natural* form of the sulphuret of mercury is that of the black ethiops or amorphous, while that of the red or crystalline is a *forced* one. There is a constant return from the crystalline to its natural amorphous condition, hence comes the gradual darkening of this beautiful color when left to the direct action of light and air. Even when not directly exposed to the action of the elements, the gradual change takes place, but in a much slower way.

Vermilion prepared by the wet process is usually more crimson than that made by the dry, and this is more likely to fade than the scarlet-toned ones. Another peculiarity of the wet process and of all crimsoned-toned vermilions is that they do not have as good a body or are not so opaque as those of a scarlet tone. Another peculiarity of vermillion is that the finer it is ground, the paler it becomes and the quicker it will fade. As a water color, when it is left unprotected from the influences of air and light, vermillion is absolutely unreliable under such circumstances.

In oil or varnish, it is fairly permanent; and when the painting has been done on a proper ground with the right vehicles, and afterward well varnished over, it will not change readily, and may be called "unfading," comparatively so at least.

Linseed oil itself, in its ordinary condition, is not a good medium for it. Gold size, japan, or a good varnish

are much better for that purpose. This is the principal reason why the coach and car painters have nothing but praise for it and are so successful in its use, while the house painters, who are used to mix their colors differently, and who also in all probability are not so familiar with the peculiarities of that color, usually have little good to say of it. The latter bring in nearly all the complaints against it.

The genuine simon-pure vermilions can be safely used with most pigments. It is only when they contain free sulphur, as in the lower grades, that there is any danger of mixing them with other pigments.

Vermilion, owing to its heavy weight or density, precipitates readily when mixed in liquids, therefore it is best to buy it in a dry state. It is found ground in oil or varnish in small cans; in reality it is not ground in them,—it is only mixed into a paste with the liquids. This the painter can do as well for himself at the shop without any waste, as he need mix only as much as he wants. The grinding would destroy the color, and manufacturers or grinders are too smart to want to do that. The coarser the atoms of vermillion, the richer and more brilliant will be the tone. The above statement is not only true of vermillion, but also applies to all colors having a crystalline nature.

A crimson vermillion is usually more transparent than the pale or finer ones, the crystals of the deep crimson variety being coarser. To this are partly due its greater transparency and brilliancy. The unbroken crystals give a reflection and depth to the finish which is remarkably beautiful. It is not so fine nor as opaque as the pale vermillion, but richer toned. But it is not so deficient or transparent but that, over a proper ground, it will cover well in one coat.

The pale varieties, being finer and more opaque, are the ones commonly used for lining or striping, and the only red that can be used to make a solid-looking stripe in one coat over black.

IMITATION OR VERMILION REDS

Manufacture and Preparation

The vermilion reds, as the imitation vermilions are now called, are fast encroaching upon the domain of the genuine or English vermilion, as quicksilver vermilion is usually known in the United States. It is really wonderful to note how much progress and how many improvements have been made in the manufacture of these reds within the past fifteen years. All but the opacity of the genuine pale vermilion has been attained in them and reproduced in the imitation. In some respects, as in permanency, some of these are even superior to the genuine.

This progress is mainly due to the discoveries in the making of alizarin and other high-grade coal-tar products. Some were formerly obtained from madder root at great cost; and later the introduction of the paradiazo reds has completely changed the output in that class of goods.

A short review will be made of the different grades of vermilion reds.

Every color manufacturer has his own peculiar way of handling or preparing vermilion reds, the usefulness of which he claims to be "just a little bit" ahead of that of his competitors, and to protect which he gives to his products a proprietary name.

The multitude of names for these reds has been the cause of no end of worry to painters and paint men who are *not familiar with them*. There can be but little doubt

that in the recent past, when every thing in the manufacture of vermillion reds was new and really in an experimental stage, there was considerable difference in the output of the different manufacturers of these reds. Some seemed to have the coloring matter much better fixed than others; but the field of search has been an open one to all, and what with the aid of chemistry and of "catching on" combined, the competing ones have not been slow to note any improvement in the other fellow's output nor in getting acquainted with it in some way or another. To-day the man who has not been able to keep up his end with those in front, has had to abandon the field or content himself with the making of inferior goods only, and he is known to the trade.

The result of this competition is that now one can safely say that all prominent color makers make good goods. All make certain lines of low-grade goods, as some trades want them. These are usually colored with a cheap aniline color thrown upon a cheap base. But as long as there are large buyers who are not willing to pay more for a vermillion red than for what a good ocher sells at, they will be catered to. These cheap reds also serve as a type to compare the crude efforts of the beginning with what has now been achieved. They fairly represent the first attempts to make imitation vermillion some thirty years ago.

The vermillion reds are all made upon a base which is dyed with a coloring agent. The coloring agent is good or poor, an expensive or a cheap coloring coal-tar dye which may be worth 25 cents or \$5 per pound. In this as well as in every other instance, the better dye costs the most money.

White lead is the usual base taken to make the crimson varieties of vermillion reds, as it absorbs a much larger

proportion of the dye stuff than does orange mineral the base which is mostly used for the scarlet varieties.

The two above-named bases are used for the best grades of vermillion reds only, and intended for vermilions which are to be brushed out or painted over by hand upon the work. But there are many other bases used, to lessen the cost and for other and legitimate purposes; for instance, as where the reds are to be used for dipping.

Such heavy-bodied bases as white lead or orange mineral would be entirely unsuited for such a purpose. Their heavy weight would soon precipitate them down to the bottom of the dipping tanks. For this purpose the lightest-weight base that it is possible to find is the one which answers the purpose best of any, and will remain in suspension in the thinning liquid a much longer time than the heavier bases without settling down to the bottom.

Whatever the base may be, or the character of the coloring agents used for their dyeing, the process of making the vermillion reds is a simple one. There can be but little difference in the manner of the handling of the various manufactures. The claims of superiority, etc., made by some on the strength of these, must be looked upon with suspicion. The superiority rests altogether upon the quality of the dye, and of course proper regard to fixing it.

The base and coloring dye is agitated in large vats and allowed to settle, and after the supernatant liquid has been withdrawn, the pulp color is placed upon filtering cloth and covered with the same. It is then put in the filters, where the liquid is pressed as dry as possible. The flat cakes are then taken to the dry-house and dried out bone hard, after which they are pulverized and are ready for market.

Properties and Uses

For distemper painting, the cheaper vermillion reds are of little value. The coloring matter fades rapidly away when exposed to sunlight, as it is unprotected by varnish. The good reds stand much better, but they will darken and become dingy, losing the charming rich tone which they possess in varnish. The cheap kinds usually bleach white if made on a white base; even those made on an orange mineral base will become of a light pink, eventually changing to white. It is therefore unadvisable to use such in distemper.

The vermillion reds which are designated as permanent reds and sold by manufacturers, are usually so to a good degree, and are really more so than English vermillion, especially the crimson-toned ones if they are used under varnish, and the varnish coating is renewed as it decays away. This is especially true of the Para red.

Coach and implement manufacturers use enormous quantities of those reds. Every country repair shop keeps some in stock. Japanning works use them and they may be said to have displaced the genuine vermillion or nearly so.

For striping purposes they have so far been unable to replace the pale English, as they do not possess the same degree of opacity. In this one instance, the genuine is likely to hold its own.

Ammoniacal vapors are injurious to these reds, and they should never be used where they are likely to be exposed to their influence. Nor should they be used for the making of tints. They are injuriously acted upon by most pigments they come in contact with. They should be used alone, just as they are.

They are usually ground fine enough for use, ready for the thinner or vehicle that is to serve for their application.

They are also found in the supply stores ground up in oil or in japan. Some manufacturers do not sell their highest grades of Para reds in any other form, claiming that they fear a misuse of the dry pigment which would hurt the reputation of the goods; there may be something in this claim, but it looks fishy.

AMERICAN VERMILION

Character and Uses

So-called "American" vermillion is not an American-made quicksilver vermillion, as the name would indicate. It is not even an imitation of it, and for that reason it is not classed with the vermillion reds or imitation vermillions, nor described under that heading.

It is a dark chromate of lead, of a very deep orange in tone. It is crystalline in the form of its atoms, and to this is due its brilliancy. It should not be ground, as grinding crushes its crystals and destroys its beauty in a great degree.

Previous to the introduction of the vermillion reds, it was much more extensively used than it is now by the implement-manufacturing interests, but to-day on account of its duller color — which may be called a brown orange red alongside of the vermillion reds, whose clear scarlet it lacks — it is very seldom used by them, as these have entirely supplanted it.

American vermillion is fairly permanent. Instead of fading, it becomes a darker brown in time. Under the exposure to sulphureted-hydrogen gases it turns black, like most all lead products.

It is still used by a very few wagon and implement manufacturers in combination with red lead, either as a sort of a trademark to distinguish it from others, or in mixtures with vermilion reds, as it is thought by some to prevent the bleaching out of the cheap reds.

CHAPTER IX

RED PIGMENTS (*Continued*)

VENETIAN REDS

History and Manufacture

As the name of this pigment indicates, at some remote time the Venetians must have introduced it to the world. It is, or rather was, a natural earth, and red earths varying greatly in tone are found in all parts of the world. In Europe, but especially in Italy and near the city of Venice to which it owes its name, it is plentiful. Similar reds have been in use from times immemorial in the decoration of many objects by the ancient civilizations whose long-hidden remains of art have been brought to light in the recent past.

All these natural earths of a red tone owe their coloring matter to ferric oxide, and therefore vary greatly in tone, in the quality and in the percentage of ferric oxide contained in them. This is to be expected, and it could not be otherwise. The base or earth upon which the ferric oxide has become associated varies with each bed from which it is taken. Therefore there is not and cannot be any standard whereby to judge the value or purity of these reds.

The above does not apply to what is now known as Venetian red, which is made artificially. These artificial reds can be depended upon, not only as to the coloring and its uniformity, but also in the quantity

contained in a given weight. The late William C. Wilson, whose name has been mentioned elsewhere, describes its manufacture minutely in an essay published in *Painting and Decorating* a few years ago. The essay is too long for reproduction in full for the purposes of this treatise, but the main features of it are contained in the following description: "Venetian red, like ocher, owes its coloring to oxide of iron. Oxide of iron does more for color than any mineral. Venetian red is made in various ways. If copperas be placed in retorts and subjected to a high temperature, fuming sulphuric acid will distill over and a red material will remain. This red residue when reduced to a fine powder by powdering and levigation, becomes *colcothar*, *crocus* or *rouge*, and is a pure oxide of iron. It is mixed with gypsum in varying proportions as desired, or up to a fixed standard established for certain brands. The so-called English Venetian reds are of this character. The standard adopted for a first-class article of Venetian red is about five parts of gypsum to one part of the crocus. Gypsum is sulphate of lime, and experience has proven that it is one of the best bases for colors, and that Venetian reds made from it and crocus are good paints. The Venetian reds are coarse and require considerable labor to bring them to perfection. On this account, it has been customary to consider Venetian red when ground in oil as a coarsely ground color. Finer grades of red are prepared that are not only finely ground, but are made with a smaller percentage of gypsum, and then they are known as super Venetian reds or Turkey reds.

"Gypsum is not alone used as a base for the crocus; barytes and whiting are frequently used for the purpose. The great weight of barytes and its little power to absorb and combine with oil renders it a very undesirable base, the red so made having none of the durability of the

gypsum red. To the paint grinder, it saves a large percentage of linseed oil in grinding, and that is the costliest part of it.

"A gypsum red requires from 25 to 30 pounds of oil to every hundred weight of the color to grind it — a barytes red requires only 12 to 15 pounds for the same quantity.

"But this is not all the saving to the grinder, for the mills will grind nearly twice as much of the barytes reds as they will of the gypsum reds in the same number of hours, and the former will look smoother than the last, and require smaller packages to hold it in.

"Whiting makes a better base than barytes, but it is still inferior to gypsum, its chief attraction to the grinder being the smooth-looking paint it makes.

"All reds made by copperas are deep in tone. Certain ocherous earths are found which on "furnacing" or calcinating will give bright reds, and some of these give very light shades."

The terms American Venetian reds and English Venetian reds mean very little to-day other than as designations for the low and high qualities of that pigment. The better or higher qualities are sold under the name of "English" Venetian red, and the poorer qualities under the name of "American."

As good qualities of Venetian reds are made in America to-day as any that are produced in England, and importations of this pigment from that country are very much reduced. The good grades of the reds made in the United States are branded and sold as English Venetian reds. The name signifies quality only, and ours of the same excellence are as much entitled to it as the imported.

Large manufacturing plants exist and have been in operation for years in Philadelphia, Pa., Worcester, Mass., and on a smaller scale in other localities.

The so-called American Venetian reds are principally barytes and crocus mixtures, or a calcined ocher of poor quality and but one degree removed from a Spanish brown, much of which is prepared and marketed from Baltimore, St. Louis, etc.

Many more pages could be added to the above in describing the processes used in the manufacture of the higher grades of Venetian reds, but they are too intricate and lengthy to be of interest to the general reader, and would be of value only to the color maker.

Properties and Uses

It is enough to say that Venetian reds made upon a gypsum base will prove much more satisfactory for the painter's purposes than the others. Gypsum seems to have the property of holding up the color and keeping it from fading, or rather of keeping it from darkening, as is natural for the crocus or oxide of iron.

It has been seen that Venetian red is an artificial color, and that therefore it must contain, and in fact does contain, varying quantities of ferric oxide. So one must be prepared to allow considerable latitude for variations in this regard. A good sample should not contain less than 20 per cent in its composition. Again, the mere reading of an analysis would throw but little light on quality, as some of the poorest of the natural calcined earths which are sold as American Venetian would show up a very much higher percentage of it than the best of the gypsum-base made ones usually do. Some of these cheap calcined earth reds show from 25 to 65 per cent of ferric oxide in their composition — such as it is. Most of these are only fit for the mortar heap as colors, and the difference in cost is so slight that they should never be used as pigments for painting when the better qualities

can be had — even if it were at a much greater difference in cost than that which really exists.

Venetian reds made upon a gypsum base are reliable, and practically unchangeable by exposure to light and air. They darken a trifle, but that is caused chiefly by the darkening of the linseed oil by age. There is a cause for this belonging to the pigment itself, and that is the absorption of a small percentage of hydrogen from the atmosphere, and of a partial hydration of the oxide converting it into hydrate-ferric oxide. This is very slight and hardly worth reckoning in the gypsum-based reds.

Venetian red, either the natural or the artificial, may be mixed with other pigments with perfect safety, and it is invaluable for mixing with white lead for the compounding of many tints.

It can be used for any kind of painting in oil or distemper. The better grades contain an excellent body or opacity, and usually will cover solidly over any other color on which they may be applied in one coat.

It is used as a ground coat somewhat lightened up with white pigment, for the more expensive reds in coach or carriage work, for the reds used in painting agricultural implements and machinery of all kinds. It is one of the few colors that cannot be spared, and if lost (which it is not likely to be) could be replaced by no other red pigments.

INDIAN REDS

Production and Preparation for Use

This most excellent pigment has been known from the earliest ages under various names, usually derived from the countries from which it was formerly produced, as Indian red from India, Persian red from Persia, and so on. By far the greatest quantity of it that found its

way into England, and from thence was exported to America, was shipped from Bengal. Hence its name of Indian red, by which it is best known in both countries.

It is a very rich hematite iron ore. Its coloring matter is peroxide of iron. It is an anomalous red of a purple-russet hue, and highly valued when of good quality for its lakey tones in making tints by compounding with a white base.

It is a coarse powder in its native state; full of hard and extremely brittle particles of dark appearance and sometimes magnetic. It is greatly improved by grinding and washing. Its chemical composition is such that it has a tendency to deepen. It is most permanent; neither light nor impure air, mixing it with other pigments, time nor fire, seem to cause it to change in any way.

Being very opaque, it covers remarkably well. The tones of Indian reds vary greatly in their hues; that which is rosy being considered the best, as affording the purest-toned tints.

As long as Indian reds were imported and consisted of iron ores, and until such recent times as the eighties, there was and could be no recognized standard of purity for it. Containing great strength of coloring matter, it was the usual thing to adulterate it with from 50 to 75 per cent of makeweight foreign matter, and still it remained strong enough to disarm the suspicions of the painters of that period. Now, however, it is different. No Indian red can be recognized as pure that does not show upon analysis at least 95 per cent of peroxide of iron, and frequently some are found to analyze 97 and 98 per cent pure. The reason for this great purity is that to-day most of it is made artificially, as pigments having iron as a coloring agent are nearly all so made. It is thus possible to maintain a specific standard of purity in the processes of their manufacture.

It is made in a similar manner to that related of the manufacture of *crocus* used in the production of Venetian red, with this difference, that instead of sulphate of iron being the source of supply, iron pyrites replaces it. The processes vary to some extent from that also ; these are too complicated for description here, but may be inferred. The sulphuric acid is driven from the pyrites, and the residue forms the base of the Indian red.

Properties and Uses

A peculiarity belonging to all iron pigments, and also common to Venetian red, is that the lighter the tone, the stronger it will prove in coloring matter; thus the darkest shades of them are the weakest in this respect. Hence the rosiest of the Indian reds are the strongest.

Indian reds are selected and graded according to their shade, and it is usual for color grinders to put them up in three different shades—the pale, or rose toned ; the medium or the one between that and the dark which makes the violet shades. The pale produces the rosy tints, and the dark the lilac-toned ones. Indian reds are chiefly useful for the making of a wide range of beautiful tints associated with a white base. It is also used as a self color, but in a very limited way.

It is employed by all classes of painters, decorators, and artists for painting in oil, in japan, or in distemper, and with universal satisfaction.

TUSCAN RED

Manufacture

Tuscan red is a compound color; properly it is an *enriched Indian red*. All that has been said of Indian red, applies to it in a great degree, as that pigment is the

base. The enrichment is due to the use of a lake to dye the Indian-red base and give it the beautifully subdued crimson tones.

As usually the Indian red is entirely too strong, its strength is reduced by combining it with barytes, whiting, or gypsum. The combining is done in a tank by the addition of water with trituration. While still in a diluted state, the lakes are added to the mixture. The color is allowed to deposit, when the supernatant water is withdrawn, the pulp color pressed out, dried and pulverized, packaged, and sold as Tuscan red.

Properties and Uses

It stands to reason that the better the lake used in dyeing the Tuscan red, the better that will be in quality. If the red has been colored up with the cheaper and inferior aniline dyes,—as in making the qualities of Tuscan,—it will fade away upon little provocation, and prove as fleeting as rose pink and as prompt in disappearance.

Again, in the best grades of Tuscan reds the enriching lake is practically permanent, or the manufacturers could never guarantee them to stand 350° F. of heat before any sign of changes taking place in any way. Tuscan reds made thus are therefore very permanent, and are extensively used for the painting of passenger cars, one of the most rigorous tests for any color; they are also used with good results in the painting of steam pipes, radiators, etc., another very hard test of the permanency of a color; probably Tuscan red is more extensively used for such painting than any other color. The quality test is the all-important one for this pigment. The test for mere strength of the amount of coloring matter contained amounts to nothing, Tuscan reds being never used for the making of tints. In this regard they are very inferior

to the Indian reds. They are used exclusively for solid self-painting, and for this purpose are very much better adapted than are the Indian reds, because they possess far richer tones.

It is really difficult to test Tuscan reds. The staying quality of tone is what counts with them, and that is not easily determined on the spot — time only can do that. Some of the very poorest ones will show up bright and rich when first taken out of a can. This is where confidence in the name of the manufacturers will have to decide which of two samples one shall buy. If they have an established reputation made for their Tuscan red, let that guide. When so found, better be slow in changing to another that is unknown.

It is used by many manufacturers of machinery and implements, and when it is properly striped with a light orange it presents a fine effect. The machinery looks rich but not gaudy, and it is a relief from the overdone scarlet that it is customary to use for such painting.

RED OXIDE OF IRON

Properties and Uses

Within the past twenty-five years, the red oxide of iron has been so listed by many color grinders. It is a powerful red and to be had in many shades. The scarlet shade is the most preferred. These scarlet oxides are the brightest and strongest known. They should be pure, and this the scale test will reveal at once. When used in oil, it should be thinned to the last degree, as it is so strong that the color will not show at best advantage unless it is so thinned.

It is chiefly valuable for the making of tints with white bases where the least quantity of color is wanted to pro-

duce the desired effect. It is so very strong that one pound of it will turn a ton of white lead to a decided flesh tint. In other respects, it is of the same character of red as the Venetian red, and it is questionable if it will ever be able to take the place of that red even for the making of tints, because the base (gypsum) in a good Venetian red acts as a preservative to the white lead, and in a small measure helps to retard chalking. This is also partly due to the greater quantity of linseed oil which a tint so prepared will contain.

Scarlet oxide of iron, notwithstanding that it is absolutely pure, has never become popular among the painters. It is now nearly twenty-five years since it was first offered for sale in a regular way, but its growth into favor is so slow that some grinders who listed it a few years ago have abandoned it. At best it is a curiosity. Should it ever grow into favor, it would soon be placed on sale again, as it is as easily procurable as the crocus of the Venetian red. The trouble is that it does not fill a "long-felt want," and that it is only a stronger edition of Venetian red, and that is of questionable value.

CHAPTER X

RED PIGMENTS (*Continued*)

RED LEAD

History and Chemistry

THIS pigment was known to the ancients, and is of great antiquity. It was known and used in the enameling of pottery, brick, and terra-cotta by the Greeks and Romans, and was used also by them in their decorative paintings. It was formerly known under the name of *minium*, and is still known under that name in many parts of the world. It is the product of the oxidation of massicot, but it is also obtained by the calcination and oxidation of white lead. It is a double oxide of lead, massicot or litharge being the monoxide of it. Its chemical formula is Pb_4O_6 .

Properties and Uses

Red lead has the property of saponifying linseed oil to the extent of about one third of the quantity necessary to thin it for application with the brush. It is a very good and strong drier of linseed oil, and for that reason, joined to that of the saponification of it, it cannot be ground to a paste form with linseed oil as most other pigments can be, as it will solidify into a hard mass in a short time. Owing to this peculiarity, which is a common property of all the other oxides of lead, it is usual to buy it in a dry, powdered state.

Red lead is a most excellent paint for use over iron as a primer next to the bare metal. It is also a most excellent

primer for other metals, and it is becoming more important every year now that so much structural iron and steel are being used in the construction of buildings in all our large cities. Engineers and architects are unanimous in recommending it as a first or priming coat over iron, and many specify it to be applied at the rolling mills. It is the best primer that can be used for such a purpose.

Formerly it was extensively used in wagon painting for the running gears, and some factories still use it in that way. It seems to adhere with such tenacity on the wheels that it is not easily scratched or marred. The felloes of wheels painted with other materials soon show.

Like all lead pigments it is easily affected by sulphurated-hydrogen gases, and it will turn black when exposed to them. When exposed to the direct action of the sun's rays it has a tendency to bleach. This is no doubt due to the loss of some of its oxygen and to a return towards a monoxide state, the normal condition of the lead oxides.

As to its wearing qualities, there is nothing in the line of pigments that equals it. It becomes nearly as hard as a coat of metallic lead itself — some say harder. As has been said, a wagon's running gear painted with it will stand knocks, friction, and anything in reason without the paint coming off, while any other red would come off to the bare wood.

At the several navy yards of the United States, but especially at Norfolk, Va., the authorities have come to the conclusion that there is nothing to equal it for the priming of iron, and they specify its use for that purpose in ship construction. Again, when at the end of a cruise ships come in for a general overhauling in the dry docks, and after the old paint has been burned off, they are invariably treated to a coat of red lead as a foundation for whatever may be wanted to go on top of that.

On account of its heavy weight, it is never used in distemper; and from its tendency to blacken under the action of sulphurous fumes and to lighten under strong sunlight, it is never used for that kind of work.

Its chief and best use is when associated with linseed oil for the purposes already indicated.

Many of the white lead corroders also make red lead. This they put up in wooden kegs of same weights as those of white lead, viz., 12½'s, 25's, 50's, 100's, 200's, and 250's being the usual quantities. It is usually pure when the label says "Strictly Pure," and is accompanied by the name of the corroding firm. There is some difference in the qualities of it, some being more crystalline than others, and therefore richer in tone. It therefore requires some little knowledge of brands to be able to buy the best without seeing them first. For the priming of structural iron, this does not make any material difference; but if the lead is to be the finishing coat, as in wagon-gear painting, then that is another story.

The above ends the list of useful red pigments employed in general painting; the remainder are mainly compound pigments and the lakes, which are seldom handled in general painting excepting in tinting or coloring walls and for decorative purposes. The car and carriage painters, however, use some of these extensively. The japanning works also use them, and some are used for enameling pottery and colored brick.

LAKES.

General Remarks Concerning Them

Under the generic name of *lakes*, a class of pigments is placed upon the market which differs in one respect from all the others. As a rule they are transparent, and

are never used alone as a covering coat in oil painting. When used in oil or varnish, it is over some other coat of color which sometimes is similar in tone to that of their own, but which has made a solid covering, and they are used in that case for enriching it. Or if placed over a color which is dissimilar in tone to their own — one that will show through their own coating, which permits certain effects to be thus produced which would not have been possible otherwise. This is called *glazing*, in the parlance of the craft. That is their chief use in oil or varnish. Some also make beautiful tints with white lead or zinc white bases, especially the latter, and that with any of the vehicles.

Lakes are extensively used by the wall-paper manufacturers, and in distemper by all classes of decorators and artists. The car and carriage trades also use them largely, and artists would hardly know how to get along without them.

Lakes are invariably made by the use of a dyeing agent upon a base that it is calculated will best hold it. For this purpose, many substances and combinations of them are used. Alum is commonly the principal one, but gypsum, whiting, and barytes are also employed for the purpose.

RED LAKES

Among the reds are to be found some of the most valuable and permanent of the lakes. This permanency was originally due to the use made of coloring matter extracted from the *madder* plant. This is now obsolete, as the same coloring substance which was at one time extracted from the madder root is now much more economically extracted from coal tar as *alizarin* and *purpurin*.

ALIZARIN AND PURPURIN

Extraction and Preparation

Church says: "Both of these coloring substances are now made from anthracene. This compound occurs in coal tar in a crystalline fluorescent hydrocarbon $C_{14}H_{10}$. By a series of processes this substance gives rise to alizarin and purpurin, which are in all respects identical with those coloring matters derived from the madder plant itself. The artificial alizarin of commerce contains several other coloring matters, two of which are better known than the others: these are anthrapurpurin ($C_{14}H_8O_3$) and purpuroxanthin ($C_{14}H_8O_4$). Purpuroxanthin is also present in the natural pigments derived from madder root, but it exists in smaller proportions. Of all these compounds alizarin is the most important and best known, and yields lakes having various hues of crimson, rose, purple, violet, and maroon according to its purity, its concentration, and the nature of its base (alumina, iron oxide, or lime with alumina) with which it is associated. The purpurin and anthrapurpurin resemble each other closely, and give pigments which are generally characterized by more orange and red hues than are those obtained by alizarin. The rose and pink madders and madder carmines of commerce are generally so manufactured as to include for their coloring constituents much alizarin and very little purpurin."

The process of extracting alizarin and purpurin from madder root or from anthracene is far too lengthy and complex for this treatise. It suffices to know that it is now possible to obtain, at a comparatively low cost, excellent pigments which twenty-five years ago would have been very expensive.

Manufacture of Lakes

The preparation and manufacture of lakes from eosine, anilines, alizarin or purpurin, present no difficulties. Of course, one must be provided with the proper manipulating devices.

Madder lakes can be readily prepared from alizarin and purpurin, by dissolving those substances in the smallest necessary quantity of alkali, such as ammonia or sodium carbonate, or some pure, freshly precipitated and thoroughly washed aluminum hydrate. While the above directions are simple, there is more to that simple process than appears upon the surface. There are many little tricks of the trade that are secrets, and which are used in the precipitation of lakes, which enable one color-maker to produce from the very same substances a lake that looks brighter or which is more permanent than that made by another manufacturer.

Fixing the coloring matter is an important item in the manufacture of lakes. As an illustration of how trifles affect coloring matter and its durability, an incident, the truth of which can be vouched for, is given as follows: The world-wide known and justly celebrated government institution in France — the "Gobelins" — where the famous historical tapestries are manufactured, prepares all the dyes used in the coloring of the wool. In earlier days there were no underground sewers in that part of the city of Paris, and surface streams were depended upon for the carrying away of all sorts of liquids. It happened that a small brook formed the middle of the street in front of the factory, and that the water used for the preparation of the dyes was taken from it. The water was very impure and fetid, as it was contaminated with animal matter from an abattoir (slaughter house)

above it. In the course of the city's improvement, the stream was diverted and made to flow into underground sewers, so that the Gobelin factory was forced to use city water in compounding its dye stuffs, but some of the most admired shades could not be reproduced. It puzzled the heads of the institution for many years, searching for the cause of their inability to reproduce the beautiful colorings made in former years. At last they hit upon the cause, and, as nearly as possible, they artificially contaminated the pure water furnished by the city to resemble that which they had once used, and thereupon they were able to reproduce the shades as of old. These were due to the impurities contained in the water. This illustrates why it is that some manufacturers are able to and do put out brighter and better goods than another can. This is due in many instances to the *water*, or rather to the composition of the water used.

ROSE PINK

Properties and Uses

Rose pink is a very cheap lake of purplish-red tone, and about the poorest one in the whole range of red lakes. Its coloring matter is evanescent. It should never be employed for lasting work.

It is used for coloring fillers in furniture factories, also by some for staining cheap furniture and chairs. It looks rich, and usually remains so long enough to enable the furniture manufacturers to dispose of the goods before it disappears.

The best of it is usually made from Brazil wood; some of the cheapest of the cheap aniline dyes seem to have gone in the makeup of many samples of it. As there is danger to those who use this pigment — they may be

using some of the aniline-made ones — unless one is sure of the brand being a good one, it will be best to let it alone and take no chances. Much better lakes can be had which produce the same effects, but they cost more.

ROSE LAKE

Properties and Uses

This lake is just one notch better than rose pink. It belongs to the same order and tone of red, but, as usually made, is just a trifle lighter toned and more rosy. It, too, is made from Brazil wood when it is not made from something else (aniline).

Like rose pink it fades away quickly upon exposure to strong light, and but for the fact that one is charged a little more money for it than for the other, it would be hard to tell which is the poorer of the two. In reality it is simply a lighter shade of rose pink, of a more rosy tone, or not quite so purplish.

The same caution given under the heading of rose pink — not to make an indiscriminate use of it — will apply with full force to rose lake. This is also employed for the same purposes.

MADDER LAKES

Properties and Uses

Under this name will be found all the red lakes found in commerce *that are of any good at all*. Accordingly, all will be listed under the same heading, — all such at least that are made by the agency of alizarin and purpurin. These lakes have quite a wide range of tone, and cover the whole field of maroons, violets, and the pinks, including the carmine shades.

It is useless to examine them separately, as all have the same general characteristics, the difference being simply one of tone. Each of them will, of course, make a line of tints appertaining to its coloring.

All color manufacturers usually put out several lakes under fancy and proprietary or copyrighted names. Coach color catalogues and price lists are frequently a puzzle to the uninitiated because of some dozens of red lakes of whose existence but few may be aware. Many are never mentioned by the other competing firms, who have a puzzling list of their own. Dry color lists are also swelled up and loaded down with terms to the confusion of the average reader. Each manufacturer adopts a name of his own for something that is identically the same as that chosen by other competitors, each of whom calls it by a different name. This practice is highly confusing to persons who are not familiar with the trade custom nor with the exact character of the goods themselves. Therefore, if a person has been buying a red lake under the glowing name of "Morning Star," and he finds one that matches it but offered for sale under the name of "Setting Sun," he need not worry if he is forced to use the latter. In all likelihood they are identical, and he will not be disappointed in their use. The main point is to insist upon getting an alizarin or purpurin red, and the dealer's guarantee that such a lake is thus made is the main thing. Dealers who handle lakes should be able to answer such questions; and, if they were questioned a few times, would be forced to post themselves if they do not already know—and they should know—what sort of material they handle and offer for sale.

The madder reds and madder lakes are, all of them, what may be called permanent under proper conditions, and can be called so by contrast and in comparison with

those made from cochineal, Brazil wood, etc. They are very satisfactory in use. The range of color, covering as it does every shade of red, purple, and maroon, is sufficiently varied for the wants of any one. As they enter into the composition of the better class of vermillion reds, these might also be classed with them; thus the field of reds would include the scarlet tones. However, those reds are solid opaque covering goods, in nowise transparent, and they cannot be included with the lakes.

There are a number of reds made in a manner similar to the lakes, but upon an opaque base. These are used for solid painting on that account, and for that reason these reds cannot be classed with lakes.

The crimson solid-covering reds are chiefly used by the carriage trade, and are known under various names, unfortunately all proprietary, thereby causing more confusion. Of this description are the many road-cart reds, so called. The cheaper kinds of those reds are made from cheap aniline dyes, and are therefore fugitive; the better are from alizarin and purpurin, and they consequently are durable.

The scarlet and the carmine-toned lakes are intended to imitate the true carmine obtained from cochineal. This they cannot do in reality, for if placed side by side, the cochineal carmine is the richer by far *for a few days*. Change that to a *few weeks*, and the alizarin carmine will become the brighter and richer of the two. An exposure of six weeks will do that.

These lakes (the whole range of them) are useful in either oil, japan, varnish, or distemper; in distemper, however, all are less permanent than they are in the other vehicles, as these protect them.

Certain of the proprietary reds used in coach work are remarkably well-made goods, and but for the impropriety

of giving some of these a free advertisement, and also of doing sundry others, probably as good, an injustice by not also naming them — the author does not claim to have tested them all — therefore he refrains from naming any. The mention of their existence is sufficient, because the reader is made aware of their character.

INDIAN LAKE

Properties and Uses

Some few decorators and artists still cling to this lake, but there are no good reasons why its use should not be abandoned altogether. It is universally admitted to be very inferior to the madder lakes, but it is somewhat more permanent than the cochineal lakes, and that is probably why some continue its use. The excuse is a very lame one. It is far less brilliant than and very much inferior in durability to the madder lakes of corresponding tone.

Indian lake is a *lac* of a resinous character produced by various plants in the East Indies. These are punctured by the larva of the *Coccus Lacca*, and the result of the puncture is the resinous lac, from which the color is derived. It varies in color according to the plant from whence it is derived. This resin is pounded in water, the water becomes red, and after having been boiled down, the residue made by the evaporation is the crude lac dye. This is dried and made into cakes. The above suffices to indicate its provenance and character.

Its use is lessening daily, and it is only a question of time when it, as well as many other pigments which have been useful in the past,— for want of better,— will be known no more, except in history.

CARMINE AND COCHINEAL.

History and Production

Carmine is said to have been discovered by a Florentine monk, who, while he was engaged in the preparation of some medicine in which cochineal was introduced, observed a bright red precipitate. For the sale of this red, his monastery afterwards became famous.

Carmine is a coloring principle found in the body of a small insect called *cochineal*. It is said that the water used in its manufacture has a great deal to do with the beauty and brilliancy of the pigment obtained from it. Otherwise its extraction is a simple affair.

The following will explain in a few words how it is extracted. Take one pound of powdered cochineal, and add four or five drams of subcarbonate of soda or potash. When this has been boiled in soft water for a quarter of an hour, add eight or ten drams of alum. After the solution has been effected, take the receptacle from the fire, draw it off into clean vessels, and after it has stood for about a week, the carmine will be found deposited at the bottom. This deposit must be carefully dried, and then it is ready for use.

There are many other methods of extracting carmine, but the above is as simple as any, and will suffice.

Properties and Uses

Carmine is a very brilliant color when well made. Alas! it cannot long resist the action of a strong light, and it will quickly fade away if so exposed. Its place is being rapidly taken by the madder lakes, and while it must be admitted that these are not so brilliant at the start, in a very few days they appear the more brilliant of the two.

It is very rich as a glazing color over English vermillion, and is still used for that purpose by the carriage painters, although even for that purpose many of them have substituted a madder lake of similar tone, as most individuals prefer a mediocre stability to a short-lived brilliancy.

It is a pity that such a fine red should be so fugitive, and for that reason painters who value their reputations must go slow about its use, and had better let it alone.

There are many other reds that can be found listed in artists' supply store catalogues, but many of these can be placed and belong to the reds described, and the rest are for use in padding the lists; most of them are absolutely useless even to decorators and artists. Red ochers are sold under that name and a dozen others. They are natural reds, the same as the yellow ochers. All such should be, and in fact are, most advantageously displaced by the artificially made Venetian reds, as these are uniform, and have the color better fixed than the natural ocher reds, and possess the same range of color tones. There is no object in retaining the former; they cumber the red list uselessly. Many are little better than mortar colors, and are decidedly poor in working qualities.

CHAPTER XI

GREEN PIGMENTS

CHROME GREENS

CHROME GREEN is the *one green* which is most used by house painters and decorators, and for this reason it is given first place here. It has been the aim to notice the various pigments in a group according to prominence. It is not possible to do this in every instance. Frequently it is hard to choose between two which seem to have equal claims for prominence. In this instance, it is regrettable that there is no better one to head the list.

Chemistry and Preparation

Chrome green is a compound pigment, not only in the sense of many other pigments of various substances combined together, but also, in that it is a secondary color; in other words, that it is of two other distinct colors which when combined form greens, viz., Prussian blue and chrome yellow. It can be made by a simple mixture and triturating the pair.

In color works it is never so made. In these establishments they take the equivalents in chemicals of both these colors and dissolve into solutions. Then they mix these together in large vats, and the green is precipitated. This green is what is known as *chrome green* in the United States. By this process, it is claimed that the color thus produced is more intimately mixed and incorporated. Besides, it gives every manufacturer room to make the

claim that by his particular method of handling and precipitating, he is able to fix the coloring matter much better than any other maker has ever been able to do, and also claim superior permanency for the same reason.

Be that as it may, there is one sure thing, and that is, that certain chrome greens are certainly much more permanent than others. Some retain their tone much longer than others, remaining of a decided green after others of equal strength of coloring matter have badly faded. A number seem to fade very soon after application; others again, like some widows, wait a reasonable time before changing their dresses.

After the chrome has been precipitated, the supernatant water is drawn off; the pulp green is put into filtering cloths and in presses to free it of water. The pressed cakes are taken to the drying room and left there until bone dry, after which they are taken out, broken up and pulverized in the mills, and are then ready for sale as dry chrome green; or for grinding, in oil, japan, varnish, or water, for the various purposes for which it is adapted and wanted.

What has been written above, applies to the manufacture of pure chrome greens; but pure chrome greens are seldom found in the market.

Owing to their great covering properties, and amount as well as strength of coloring matter, and their great opacity, there is really no absolute necessity for their absolute purity. The reason for this is that green is seldom employed for the making of tints, as are most other colored pigments. Green is used mostly as color by itself for the solid painting of blinds for windows, wagon beds, implements, iron fences, etc. A chrome green containing only 20 to 25 per cent of actual chrome green, when it has been properly prepared upon a good base, will

cover solidly in one coat any other color over which it is painted, be it black or white. It would be a waste, therefore, to use 100 per cent of color chrome green to do what 20 per cent of it will do as well. The 100 per cent green might possibly cover a trifle more, as it could be thinned more; but as no one cares to apply too thin a color, even that would not amount to anything, and the assertion can safely be made that one pound of 20 per cent green will cover as much as one pound of 100 per cent.

Therefore by common consent all color manufacturers put out a chrome green containing three parts of base to one part of chrome green. This mixture then contains 25 per cent of absolutely pure chrome green.

The base, of whatever nature it may be or in whatever proportion it is used, is always added to the chemical solutions just at the moment of their being thrown into the vats and before the color is precipitated. The base and the color are precipitated together. This insures uniformity.

Nearly all the chrome greens are sold under some proprietary name, such as Crylight, Marseilles, Sylvan, Emerald, French Imperial, and a host of others entirely too numerous to mention; but whatever their name may be, they are all reduced chrome greens and belong to the class just described. None contain over 25 per cent of actual color in their composition.

When chrome green is used for the purpose of making tints with other pigments, either white or colored, the strictly pure greens should be used, because there they are the more economical. Such greens can be bought, but they are in little demand aside from printing-ink manufacturers, etc. Many painters make pea greens, olives, and the various light-toned tints of those and other greens from ocher chrome yellows, Prussian blues, etc., which

they compound without the use of any chrome green. Hence the pure greens are not always to be found at paint supply stores, because the demand for them is very slight.

All manufacturers do not use the same base for the purpose of reducing the pure chrome green to the commercial basis of 25 per cent, and this of itself accounts for the difference found in their working qualities. Barytes is that which is most commonly used for the purpose, either alone or in conjunction with others. Gypsum makes the best base for that purpose, as it seems to hold up the color better, and it also works better under the brush. Whiting is used extensively also; and added to either barytes or gypsum to make the paste smoother in texture, it also helps out in the better brushing out of the paint.

Properties and Uses

Chrome greens come in two tones; and accordingly as it approaches to one or the other of these two, the green is so classed. The two tones are known as the *blue greens* and its opposite — the *yellow greens*. In some of its blue shades, chrome green approaches somewhat to the tone of the Paris or emerald green. There is a wide range to be found in the tones between a very pale yellow green and a very deep blue green which covers the whole gamut and chromatic scale of the green tones. Each of these two groups of green has some uses to which it is better adapted than the other. As a rule, the yellow-toned greens are stronger in coloring matter than those of a corresponding depth in the bluish ones.

One peculiarity that belongs to all chrome greens, but in a much stronger degree in the blue than in the yellow ones, is that no matter how carefully they may have

been made, if there is any supernatant linseed oil when a can of chrome yellow is cut open the oil shows up tinted with blue as if the blue had separated from the yellow. This property is inherent and does not hurt it. The necessary trituration of the color before using it will remedy this condition and reincorporate the trifling amount of dissolved Prussian blue.

Some of the well-made chrome greens are fairly permanent; but, as any one may well surmise, anything that would destroy the color of Prussian blue — such as lime or other caustic substances — will also destroy that color in the chrome green combination. Sulphureted-hydrogen gases which affect chrome yellow, will in the same manner destroy the color of chrome yellow in the composition of the green. So these greens have to carry a double load of liability to being injuriously acted upon.

Notwithstanding that chrome green is anything but absolutely permanent, to all intents and purposes it is sufficiently so, that, for want of a better, it may be fairly depended upon for many situations and certain conditions.

It is used by all classes of painters, in oil, in japan or varnish, and in enameling or japanning works. It is also very useful in distemper work if care is taken in mixing it that none of its incompatibles be compounded, or it would then surely fail.

In whatever vehicle it is used, it is contra-indicated if it is subject to any of the influences which would act injuriously upon either chrome yellow or Prussian blue — as under the heading of either of those colors, this is fully given, and it is unnecessary to repeat it here.

Chrome green and all the proprietary greens — which, as we have seen, are all chrome greens — come in several shades. Manufacturers pack it up in cans as: Extra

Light, Light, Medium, Dark, or Extra Dark, each of which makes an entirely distinct set of tints with a white base.

To ascertain the value of a chrome green, it is proper to make a scale test of it alongside one of the same grade that is of known standard. With that test one can readily determine the amount of coloring matter it contains.

One should never take a strictly pure green to judge values, and expect one of only 25 per cent of claimed and acknowledged purity to come up to it. If, however, four times as much of the commercial grade is taken as is of the strictly pure, the tints made should be equal.

The reader will find full directions of *how* to make these tests at the end of Chapter VI under the heading Chrome Yellow.

GREEN OXIDE OF CHROMIUM

Properties and Uses

The green oxide of chromium is known to the artists and decorators of the world under many names, and in reality is the only green entitled to the name of *chrome green*, for it is that. But what we know under that name in the United States is a different pigment, which, while it is not entitled to it, is the only one here known by that name.

Life is too short to start a crusade and to make a quixotic fight against windmills — which it would be if the effort were made to change the name—and it is simply accepted through sheer compulsion; it cannot be helped.

Green oxide of chromium is a good enough name if it is a bit long in the saying; as it is, it is so seldom used that it matters but little anyway. Many of the proprietors of paint supply stores would be puzzled if one was to call for it, and would not know what was meant.

Owing to its limited use, but little need be said of its manufacture. The intricate processes of manufacture make it an expensive pigment, and that alone will always prevent its use, even if it possessed much better qualities than those which are inherent in it. So that with the cheap imitation chrome greens, which cover better and cost ever so much less, there is little danger of it ever coming into popular use.

Two distinct processes are used in its manufacture, and these are known as the *dry* and the *wet*. Accordingly as it is made by the wet or the dry process, this pigment is either transparent or opaque. The latter is the usual condition under which it is to be found in artists' tube colors. When made by the wet process the sesquioxide is thrown down, and that makes it transparent. It is therefore useful both as a solid color for opaque painting, or the transparent for glazing purposes. This pigment is somewhat more permanent than the so-called American chrome green goods which are known and sold here as chrome green, and it can be mixed with most of the permanent pigments.

COBALT GREEN (ZINC GREEN)

Properties and Uses

This valuable pigment deserves a more extensive use than that which it has so far received in the United States. In Europe, especially in England, France, and Germany, it is much more popular than it is here. In America, it is mainly found in tubes for artists' use, and is seldom ever offered in any other shape. It is imported, and if manufactured in the United States the author has never heard of it. There is no reason why it should not be made here. As I am not familiar with its preparation,

I give the following extract from Church's "Chemistry of Paints":

"It has long been known that the oxide or a salt of zinc moistened with a solution of cobalt nitrate and then strongly heated before the blowpipe gives a porous mass of a beautiful green hue. This compound or mixture of the oxides of zinc and cobalt may be prepared by: 1st, Precipitating with an alkaline carbonate a mixture of the nitrates of cobalt and zinc, and then strongly heating (after washing) the precipitate formed thereby; 2d, Making a paste of zinc oxide and water, and adding a solution of nitrate or sulphate of cobalt or roseo-cobaltic chloride; the mass is then dried, calcined at a dull red heat, thrown into water, ground, washed and dried. Method No. 2 gives a finely colored product, the depth of hue being proportional to the percentage of cobaltic oxide. If the latter oxide amounts to one third that of zinc, the color is a very deep bluish green; with no more than one sixth, the color is still rich. Some specimens do not contain more than one twentieth, — occasionally even less of cobalt oxide, — and yet they are far from pale. An excellent deep sample contained 12 per cent of cobalt oxide.

"When properly made, cobalt green is a pigment of great beauty and power. The deeper tones of cobalt green are almost transparent in oil. The pigment works well, is quite permanent, and has no action upon other pigments. Cobalt green is, in fact, one of the two rare pigments which are at once, chemically and artistically perfect. It must be admitted that it is almost exactly imitated by a mixture of viridian and artificial ultramarine with a little zinc white.

"Cobalt green is again coming into artistic use, as it is equally well adapted for all methods of painting. It

was discredited awhile by the inferiority of the product obtained by Rinmann's original process (No. 1 above)."

It ought not to be an expensive pigment, and if manufactured here upon a large scale its cost would be low enough for use in general painting.

Sometimes the green is prepared by precipitating a cobalt salt with an alkaline arseniate or phosphate, and then heating the precipitate with zinc white.

Cobalt green, as was seen above, is more or less transparent according to its depth of tone. The lighter tones are much more opaque, and these would be the best for solid painting, but the deep ones used as a glazing coat over other greens give rich effects. This pigment is good in any of the usual vehicles, and it is hoped it will become better known to the general trade. It would be invaluable to the carriage and car trade; and decorators should use it more in interiors, where it is free from attacks of the deadly enemies of most other greens.

VIRIDIAN

Properties and Uses

Again recourse is had to the same source for information concerning viridian. Church says of it:

"About eight parts of crystallized boracic acid and three parts of potassium bichromate are thoroughly mixed and calcined. The mass so obtained is treated with cold water and washed by decantation, ground wet, washed with hot water and carefully dried. The product is an hydrated chromium sesquioxide in which a variable amount of the boracic constituent frequently remains. Viridian, however, is essentially an hydrated sesquioxide of chromium, having the formula of $\text{Cr}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$.

"The color of viridian is a very deep bluish green of great purity and transparency. It furnishes with aureolin on the one hand and with ultramarine upon the other an immense number of beautiful hues adapted to represent the colors of vegetation and water.

"It is quite unaffected by sunlight or sulphureted hydrogen, and it has no evil action of its own upon other pigments. Moreover, it can be safely used with all the painting media and upon all kinds of painting grounds."

It should be more extensively used by the carriage trade, as it is just the sort of pigment that is needed for a permanent glaze.

It is chiefly imitated by compounds of chrome yellows and blues, but such are worthless; they possess neither the brilliancy nor the permanency of viridian.

Its use is confined to the artist's palette and to the decorators.

CHAPTER XII

GREEN PIGMENTS (*Continued*)

TERRE VERTE

History and Production

THERE are to be found in various parts of the world, in the New as well as in the Old, certain earths having a variety of greenish tones. These earths vary greatly in their composition, as one might well suppose, and in consequence of this are diversified in their respective colors.

Terre verte was made use of in the earliest attempts at decoration, and is found upon ancient Roman wall paintings. The prepared pigment itself has been discovered in pots in the ruins of the city of Pompeii.

None of the various shades of this pigment are at all vivid, and all partake of the tertiary order.

It is prepared for use in much the same manner as was indicated for ocher and the other earth pigments which already have been under notice — by washing or levigating to free it from its heavier impurities, and, afterwards, separating into various grades, then drying, pulverizing, etc.

The following analysis, made by A. H. Church, is that of a sample from Monte Baldo in Italy. It shows that *terre verte* is allied to the hornblendes, and that it is a silicious-ferric product:

Analysis of Terre Verte

Water given off at 100° C.	4.1
Water given off at red heat	4.2
Ferric oxide (Fe_2O_3)	20.3
Ferrous oxide (Fe_2O)	2.6
Alumina	1.7
Lime	1.1
Magnesia	5.6
Potash	6.4
Soda	2.3
Silica	52.0

From the composition shown by the analysis, a person can at once infer that terre verte is little subject to change, as all its constituents are themselves the product of any and all possible change, and incapable of any further ones.

Terre verte is only semi-opaque in character, and therefore covers indifferently well when mixed with linseed oil or varnish. Its use in oil is limited to the producing of certain neutral-toned greenish hues with a white base. It possesses the quality of absolute permanency, and prolongs the life of white lead associated with it in the making of tints. It does this because of its power of absorbing large quantities of linseed oil, and acts in many respects as do all the silicate earths.

It is chiefly used in water or distemper. In distemper it covers well, and its neutral tones and that of its tints are much better fitted for mural painting than it is in oil.

Some fine samples of it have been found in various parts of New England, and many manufacturers grind it under their proprietary names. Manufacturers of mixed paints can also use it to good advantage for certain tints on account of its imparting good wearing qualities and because of its relative cheapness.

VERDIGRIS*Chemistry and Preparation*

Verdigris is the basic preparation of copper. It is a permanent bluish green, and is made in large quantities in Southern France, where the city of Grenoble is headquarters for its distribution.

It is produced from copper sheets or plates upon which the grape pomace, obtained from the wine-presses so abundant in that section, has been spread. By fermentation, the acetic acid is combined with the copper, and forms upon the surface a green rust which is verdigris or the subacetate of copper. It can be manufactured in various ways, but as the use of that pigment is becoming more restricted every year, and as the description of the processes would require more space than the little usage that is made of it warrants, the above, which is the principal method of obtaining it, will suffice, with this additional note, that the raw product thus obtained is afterwards manipulated to free it from impurities. It is then crystalline, and in that shape it appears upon the markets of the world.

Verdigris is a perfectly transparent pigment, and its chief use in decorative work is where that effect counts heavily.

Its main use to-day is as an ingredient in many anti-fouling preparations for the painting of ships' hulls below the water line, especially for the copper sheathing placed upon the bottoms of wooden vessels. It is claimed that barnacles and other sea pests which love to attach themselves to ship-bottoms — thereby causing in the roughness of their uneven accumulations an impediment that results in more friction and lessened speed when plowing through the water — that said pests will not attach

to vessels whose bottoms have been painted with it. The poisonous character of that pigment may have something to do with that; possibly it kills them. At any rate, their number is greatly lessened when such bottoms have been painted with verdigris. Sulphureted-hydrogen gases darken verdigris. It is not safe nor suitable in any way to use it in water colors, nor is its use in oil desirable, although when mixed in that vehicle it is at its best.

It is poisonous, and while not of as violent a character in that regard as that other copper-base pigment, Paris green, hereafter described, it is bad enough in that respect even for use in making a successful suicide. One must exercise some caution with it.

The use of this pigment has been replaced by that of other greens, and it is almost exclusively confined to anti-fouling paint for ship-bottoms.

It is still used as a glazing color by a few old-fashioned carriage painters.

MALACHITE, OR GREEN VERDITER

Properties and Uses

Under the name of *malachite*, a natural green carbonate of copper has been a long time in use as a pigment. It is mined in various parts of the world, freed from its impurities, and treated in sundry ways. Its formula is $\text{CuCo}_3\text{CuH}_2\text{O}_2$. It resembles in composition the azurite or blue verditer, but contains less of the copper carbonate.

It is fairly permanent, but acquires a dull brownish hue, due to the darkening of the linseed oil; is not safe as a water color, therefore inadmissible for distemper work.

It is so seldom used now, even by artists, that it will be cut off with the above mention and with a parting warning for paint students to leave it alone. It possesses no peculiarity of tone but such as can be obtained by the use of less dangerous pigments which can be depended on as having greater permanency.

EMERALD, OR PARIS GREEN

Chemistry, Preparation, and Uses

Paris green is the name under which this pigment is best known in the United States. It is a beautiful, most rich and brilliant, transparent green, but for all its beauty, its violent poisonous properties unfit it for the use of the house painter, and it is only with the utmost care that it should be employed by the coach painter as a finishing glaze. There is, of course, nothing like it for this purpose, and hence it is that one may be excused in taking some risk in its application. With a great deal of care and by the wearing of a sponge at the nostrils during its mixing and manipulation, the danger is reduced to a minimum. It affects some painters more injuriously than others. Some men can never work with it without it making them sick; such should never use it.

Its use as a glazing color in vehicles is questionable, to say the least. For a time, while it is protected by good coats of varnish, it may be safe enough. But when the varnish decays, and is not promptly replaced, there is always some danger of particles of it becoming absorbed into the human system, especially that of children. They know nothing about the dangerous qualities of the paint, but, attracted by its beauty, are tempted to rub their hands over it, and become poisoned. When a death occurs (and many have happened) from such a

cause, what useless regrets it must cause. Therefore the reluctant advice is given — let it alone.

This pigment is cupric aceto-arsenite, and is permanent in oil. In water colors it is not, and will not long remain untarnished in impure air.

SCHEELE'S GREEN

Characteristics

Scheele's green, or cupric arsenite, is another copper pigment. It is an arsenite of copper, and its process of manufacture need not be given, as it has become obsolete. In every respect but one, it is the inferior of Paris green, and that one is, that, if possible, it is even a stronger poison. As is the case of many another pigment for which generations of painters once found some uses, its use today is about *nil*, and it has been replaced by others better adapted to any of the purposes to which it was put by old-time decorators. Its place at the tail end of green pigments is well deserved.

Owing to its frequent mention in the antiquated literature of painters of the eighteenth century, it was thought best to list it here, simply as a warning example and to advise against its use.

CHAPTER XIII

BLUE PIGMENTS

ULTRAMARINE BLUE

Chemistry and Manufacture

ULTRAMARINE BLUE is one of the conquests of science of which chemistry may well be proud. As a pigment, in its natural state it has long been known. It can be obtained in its natural state and condition from lapis-lazuli, a semi-precious stone. There is little danger of the natural ultramarine ever becoming a dangerous rival of the artificially prepared; and if it had to be extracted from the stone now as formerly, it would hardly be employed as lavishly as it is to-day.

Chemistry, however, revealed its composition; and ever since, its artificial reproduction has permitted it to be furnished at a nominal cost, and put it within the reach of any one, whereas formerly royalty only could have afforded its use as profusely as the average whitewasher could do to-day.

The processes of manufacturing it artificially are well known, but are very intricate; and until within a comparatively short time, this pigment was imported from Europe. To-day the largest works in the world are located at Newark, N. J., and produce as good an article as can be imported from anywhere. All the raw material that is used in the manufacture of ultramarine is cheap; it consists of kaolin, or china clay, silica, sodium sulphate,

sodium carbonate, sulphur, charcoal, and rosin. Calcined alum is sometimes used instead of kaolin. After heating the ingredients together in crucibles and then cooling, a greenish porous cake is found, which is powdered and roasted (after the addition of sulphur) for several hours. It requires several powderings, washings, and dryings, also further calcinations to develop the proper blue color.

To prepare it for use requires some careful manipulation. It should be washed with water free from lime, and requires to be finely ground. This improves the color very much, and any soluble impurities are removed by these washings.

Properties and Uses

The range of color is great in this pigment. It runs from a pure blue to a purple blue, and some shades even border upon the green, and are called *green ultramarines*. However, they are not true greens, and they cannot be listed among them. The shades that are free from purple are accounted the best, and for the purposes of the painter are certainly superior, as it is very easy to make a purple-shaded tint from a blue ultramarine, but it is impossible to make a clean blue tint from a purple tone of the same.

Ultramarine should never be mixed with white lead for the making of tints, on account of the sulphur it contains. When it is used with a white base for that purpose, zinc white is much the best, and the tone of the tints will be cleaner and purer-looking.

Sulphureted hydrogen does not affect artificial ultramarine blue, neither does lime and other alkalies. Weak acetic acid or a saturated cold solution of alum does affect it, and in time will destroy it. It may be called a per-

manent pigment, as sunlight does not impair it, and it is useful in either oil, japan, varnish, or distemper; but to be safe, it should not be used in connection with pigments that have acetic acid or alum in their composition. It is always safe when used alone as a solid color or with zinc white for the making of all blue tints.

The coach painter finds good use for it, both for the painting of solid surfaces and for the glazing of them with the transparent kind. As this pigment is usually prepared, it covers fairly well, but it is inferior to Prussian blue in this regard.

There is no particular standard whereby to judge of the value of this pigment other than that it should be of good blue tone, that it should cover well, and that it should be strong in coloring matter for the solid varieties; but the last two items do not apply to the kinds of it which are made upon a transparent base and which are intended for glazing.

It is also extensively used for house painting, in the making of tints with zinc white, as these stand well, and remain unaffected by sunlight, which cannot be said of those made with Prussian blue.

For distemper, it is also very useful for wall work and in decorating.

This pigment may vary a good deal without any intentional adulteration of it. But, intentional or otherwise, it should be up to some good sample, which can be selected and preserved for comparison with it. Therefore the only rule to judge it by, and the one point upon which all would agree, is purity of its blue tone and brilliancy.

It comes to market in its dry state in boxes containing 28 pounds. It also comes ground in oil, japan, or varnish, as well as in water for distemper painting.

PRUSSIAN BLUE

History and Chemistry

This pigment really deserves to be placed first upon the list of blues. It is probably used the most of all the blues by painters and decorators, but, owing to its being more fugitive in sunlight than ultramarine, it was thought best to give it as second on the list.

Its history now dates back nearly two centuries, and its discovery was accidental. One Diesbach, in 1714, while he was precipitating a solution of alum to obtain a white base for the manufacture of lakes, used some potash that had been rectified with animal oil, and instead of precipitating a white substance, it precipitated a blue one. He had purchased the potash from a man named Dippel, who, having been informed of the occurrence, traced it to the proper cause and was able to produce *Prussian blue*. The process was kept a secret as long as possible, but in 1724 it was discovered by Woodward, and by him made public.

Its manufacture is as simple as can be, and is done by various processes, the necessary agent being prussiate of potash. This is obtained by fusing the potash of commerce with blood or other animal refuse. After careful preparation, it is of a yellow color. It is added to another solution made from two parts of alum and one part of sulphate of iron, the mixture filtered and allowed to settle. A double decomposition ensues, in which the iron combines with the potash of the prussiate, forming a sulphate of potash, while the prussiate of iron is thrown down, the sulphate of potash being held in solution.

On the other hand, a similar decomposition takes place with the alum, and the superabundant carbonate of potash is mixed with the solution of prussiate of potash.

By this means a sulphate of potash is formed, and the alumina or base of the alum is precipitated. These two precipitates, prussiate of iron and alumina, are produced at the same instant of time and are intimately mixed, producing a substance of a brilliant and intense blue, the Prussian blue of commerce; this, of course, after it has been well washed and dried.

Whatever may be the system and methods of manipulation,—and these may differ greatly,—the equivalents of the above must be present to produce Prussian blue.

Properties and Uses

Prussian blue is a transparent pigment of great strength of coloring matter, capable of absorbing enormous quantities of linseed oil. On account of the fineness of its particles, and the still greater fineness which can be given them by thorough grinding, Prussian blue is held a long time in suspension before precipitating in that vehicle.

Plow and implement manufacturers use it to paint over polished steel parts to preserve them from air or moisture, and consequent rust. In the diluted condition in which it is used for that purpose, it is thinned out in the proportion of one hundred pounds of linseed oil to one pound of the pigment.

One may well wonder at the strength and power of coloring matter. A pound of it will tint a ton (2000 pounds) of white lead to a decided sky blue.

There are two qualities of Prussian blue, which may be thus described: Quality No. 1 is very good; quality No. 2 is good for nothing. The good should have a decided blue tone of great clearness; that is the only tone of it worth having. The other has a purplish or dirty blue-black tone, and no amount of trying to doctor it up will help any. The tints made from it are invariably sickly, miserably

muddy-looking, and never give satisfaction. Any tint made from Prussian blue of good quality and a suitable white base is very clear, clean-toned, and fairly permanent under proper conditions. In time it acquires a slightly greenish hue, but much of this is due, in part at least, to the change that takes place in the oil. When, however, it comes in contact with lime, it bleaches entirely away; even the tints of it made with a white base will suffer. All the alkalies have the same property, which is fatal to it. Therefore it is unsuited for distemper work, especially when the walls are newly plastered, and where it will come in contact with lime which has lost none of its causticity.

Soluble and Insoluble Varieties

There are two distinct varieties of Prussian blue that differ only in that one is soluble in water, and the other is not. In the United States it is customary to designate as *Prussian blue*, only the variety which is insoluble in water; the soluble variety being better known as *Chinese blue* or as *soluble blue*.

CHINESE OR SOLUBLE BLUE

Properties and Uses

Chinese blue is only a variation of Prussian blue. It possesses all the characteristics of the former with the one exception,—it is soluble in water instead of insoluble. On account of its solubility, it is seldom used for distemper painting. A damp handkerchief laid over it for a minute will extract color. It is also subject to the same vicissitudes, when it comes in contact with lime and other caustic substances, as Prussian blue.

After it has dried, when mixed with linseed oil, it is all right, and moisture will not affect it as long as the linseed

oil is undecayed. Therefore for use in oil it is probably as good as the insoluble or Prussian blue. But, as it is identically the same thing, there is no need of cumbering the color list so uselessly as with a separate pigment. Prussian being the same, and furthermore, insoluble, it is the better of the two.

As soluble blue, it has uses which are mainly in the preparation of bluing, either in the liquid form or in a dry powder for laundry purposes, for the preparation of carpenters' crayons, and many other economical purposes which are foreign to the subject matter of this treatise, and for that reason need not be related here.

CHAPTER XIV

BLUE PIGMENTS (*Continued*)

COBALT BLUE

Manufacture, Properties, and Uses

UNDER the name of *cobalt blue* there are several substances sold which claim to be it. The best known is that which is made by a combination of cobalt oxide and alumina. Thenard's blue, another variety of it, is a cobalt phosphate on an aluminous base.

The first is the less complicated, and can be produced by calcining a well-triturated mixture of aluminum-hydrate and cobalt-oxide. The greatest care must be taken that the material used in the preparation of this pigment shall be free from iron and nickel; these substances injure the purity of tone and the brilliancy of the cobalt blue.

Cobalt blue is a permanent pigment, unaffected by light, moisture, or by oxygen. Cobalt can be safely used in true fresco, as it is unaffected by lime. It can also be safely used with any of the other pigments. It is not as strong in coloring matter as ultramarine blue, and is decidedly lighter in tone.

Nineteen twentieths of the cobalt blue that is offered for sale in the United States, is compounded from a good quality of ultramarine blue and an admixture of zinc white, so that its shade may be lightened to that of cobalt

blue, and of which this makes a good imitation. This imitation, in fact, is so close that even an expert would have difficulty in detecting it. To all intents and purposes, when the pigment is mixed with linseed oil, it is fully as good as true cobalt; but if used in distemper, it is subject to the same baneful liabilities which have been indicated under the heading of that pigment, and instead of perfect security, which the true pigment would have given, there are the usual troubles arising from ultramarine.

It is, therefore, questionable whether it will pay the painter to buy this as long as there is no assurance of its purity to be had. It is just as easy to make it as it is wanted; it is simply an ultramarine tint which can be prepared by any one from the mixing of ultramarine and zinc white.

CERULEUM

Properties and Uses

Ceruleum is little known in the United States. Church, in his "Chemistry of Paints," has this to say of it:

"When oxide of tin is moistened with a cobalt nitrate solution and strongly heated, a greenish blue mass is obtained, which after powdering and washing constitutes one of the varieties of the pigments obtained from cobalt and known as *Ceruleum*. There are other ways of obtaining and preparing this pigment. One of these consists in precipitating potassium stannate with cobalt chloride, collecting and washing the precipitate and then mixing it with some pure silica. Some samples contain calcium sulphate or lead sulphate in place of the silica; these are of an inferior quality.

"*Ceruleum* is a permanent pigment of a rather greenish

blue color without any tendency to the violet cast, so noticeable with other cobalt blues when viewed by gas or candle light. It suffers little or no change by exposure to light or impure air, or by commixture with other pigments. It is a sub-opaque, rather earthy pigment with a moderate tinting power."

Although some painters find it useful, it can really become so only when used where such deleterious conditions exist as would injure the otherwise excellent imitations that can be made of it from mixing together in the right proportions, viridian, ultramarine blue, and zinc white.

It is never offered for sale in America except as an artist's color in tubes, and is likely to remain so, as the general trade can readily dispense with it and without inconvenience.

CHESSYLITE, OR BLUE VERDITER

Production, Properties, and Uses

Chessylite comes from the village of Chessy near the city of Lyons, France, or rather it is named after it. It is of the same general character as malachite, and, like that pigment, is a copper compound, but contains less hydrate and more of the carbonate of that metal. It can be produced artificially, but when it is so made it is not as permanent as the natural.

In the past century, and especially in the first half, it was much more employed than it is now. The cobalt blues and their ultramarine imitations have well-nigh driven it out of the market; and as these blues, to all intents and purposes, are non-poisonous — while chessylite is not — there can be no good excuse for continuing its use. It should be abandoned.

ROYAL BLUE — BLUE SMALT

Properties and Uses

Under the above name, glass and other vitreous substances containing cobalt and of a rich blue tone have long been known.

It is now very seldom, if ever, used, and the term *smalt* has itself become diverted from its original meaning, and is applied to coarsely powdered colored glass and also to coarsely powdered colored sand which have been artificially colored not only in blue but in black, or anything else. This smalt is chiefly used to sand grounds in sign work, the grounds having first been painted in oil color of a similar tint to the shade of the smalt thrown over it — so as to hold the latter.

Formerly blue smalt crystals were finely powdered, washed, and the lightest-weighted particles were used as pigment. Owing to its poor covering properties and the difficulty in using it, it is nearly obsolete, but as it is indicative of the origin of what is now known as *Smalt*, it is well worth notice.

There are several other blues which at times have been used as pigments either in oil or distemper. All of them are now obsolete and their place taken by better ones. The introduction of artificial ultramarine blue and of Prussian blue has nearly destroyed the trade in other blues; indigo and other vegetable blues of a similar character being too fugitive and unstable in strong light, and all of them are undesirable in many respects.

CHAPTER XV

BROWN PIGMENTS. UMBERS

RAW UMBER

Provenance and Chemistry

RAW UMBER is an earth pigment, and is found in every part of the world. As may be supposed, it differs greatly in quality as well as in composition, and its variations may well be called numberless.

The umbers which have been found and mined so far in America are very inferior in quality to that which has come to be regarded as the standard by the color trade.

The umbers mined in England and upon the continent of Europe come closer to the standard of excellence than the American umbers do; still, they fall short.

That which is found in the island of Cyprus possesses in the highest degree all the good points, consequently it is the recognized standard. Some few samples are mined in and imported from Asia Minor that are little short of equaling the Cyprus umbers, and at one time these were so abundant upon the market that umbers of good quality were named after them; and even to-day in the United States all good umbers are sold as *Turkey Umbers*.

Umbers are mined like all earth pigments such as ochers, etc., and in their natural state contain impurities which are removed by levigations in the manner described under ochers.

The coloring matter of umbers is due to both iron oxides and to manganese dioxide. To the latter is no doubt due its excellent drying qualities in oil. The following analysis by Church shows the composition of a good sample of Cyprus umber, such as is imported, and is fairly representative of what the standard of excellence should be:

Water given off at 100° C.	4.8
Water given off at red heat	8.8
Iron oxide (Fe_2O_3)	48.5
Manganese oxide	19.0
Lime	1.4
Magnesia	0.5
Phosphoric acid (P_2O_5)	2.1
Silica	13.7
Carbonic acid, etc.	0.3
	100

Properties and Uses

The color of a good raw umber should be a greenish yellow brown, upon the citrine order when dry. It is classed among the semi-transparent pigments. It can be used in oil, japan varnish, or for distemper work, and in any of the vehicles gives good satisfaction. Without doubt it is the most useful of the brown pigments to be found in the whole list. While umber is not so brilliant as the burnt siennas, it can be used for a much wider range of purposes, and it is a pure brown. The siennas, or at least the burnt, should have been classed with the reds, but the raw sienna is a true brown and this saves a double classification of it.

All classes of painters regard umber as a necessity: the house painter to mix tints from it for his drabs and the various browns; the grainer for most all of his colors either in oil or in distemper; the coach and car painter for mixing many popular brown tints; the kalsominer

and decorator for making wall tints; the frescoer and decorators for mixing into tints and for solid work; the japanner for the hundreds of browns and drabs of which it is the foundation; and the artists in either oil or water-colors. What would they do without it?

It is prepared by paint manufacturers in oil, japan varnish, and in distemper. For the grinding of it in paste form in oil, it takes up nearly as much linseed oil as do the siennas. Next to these also, it is one of the hardest of the earth pigments to grind. When ground in oil it should be clear-toned without any muddiness, and when greatly reduced in oil should not show any specks upon glass. When so thinned out it should be transparent. Quality gives umbers their chief value; the strength of coloring matter comes only second to that. The first is an easy thing to determine by one who is used to handling them. To test for quality, it should be spread out with the palette knife and smoothed over the glass. This will enable one to notice the clearness of tone, its richness and the fineness of grinding. If one has supplied himself with a line of good artists' colors in tubes, placing a trifle of that alongside of the one tested there will be no trouble in coming to a right conclusion as to the merits of the umber. It is a hard matter to convey by words, the exact look a color should have, therefore the advice given under directions for making color tests — of providing a full line of good artist colors to judge of the quality value of pigments — is again strongly urged.

The scale test as previously described, will easily detect any undue weakness in the amount of coloring matter contained, and, in a certain measure, the tints made from them will help in forming an idea of the quality of the umber. As to the strength of the coloring, one should not be too quick in condemning the weaker simply

because it may not be as strong as another. Between two umbers, equal in other respects, the better of the two is the stronger; but between two samples — one of which is greatly superior to the other in quality — the poorer may possibly be the stronger. In such a case, no mere strength can atone for lack of quality. Usually, however, the better the quality the stronger they are, so that one need not fear the making of a test for strength, as it is almost a sure thing that the best toned will be also the strongest.

The better class of manufacturers are now putting out their pure umbers under their names and also those of dependable quality in their best grade. The others under their names, also put out a pure umber, but sometimes it is not of the best quality, and in reality inferior to a good one that is adulterated. At the risk of becoming tedious in repeating it, the caution is again given: *Purity without quality amounts to little in an umber.*

Umbers are not affected injuriously by sunlight, impure air, nor ordinary heat. By constant exposure to very high temperatures, it becomes more reddish.

The *raw* umbers make permanent tints of great beauty with either white lead or zinc white, chiefly of the drab order. It is used also in the compounding of a wide range of tints with other colored pigments, and for the making of certain neutral greens it is indispensable to artists and decorators.

BURNT UMBER

Properties and Uses

It is needless to repeat here what has been said under the heading of raw umber, as very much, in fact nearly the whole of it, applies with equal force to the burnt.

Aside from its tone, which is changed to a deep, rich brown, all the rest applies to it.

As the name indicates, *burnt umber* is a calcined umber. This calcination gives its rich brown color; and in the better grades, it will be of a clear and pure tone of brown and entirely free from redness. This is indeed remarkable, and must be a peculiar property of the iron oxide contained in the best grades of umber, for such a quantity of iron oxide as was shown in the above analysis of raw umber ought to make it of a decided red brown after calcination, and the poorer sorts do show it. So far no satisfactory explanations have been given which account for this peculiarity. In the American and other inferior kinds of umber, the reddish tone shows up, and that is a "dead give-away" as to their provenance and quality; so to correct it, these cheap umbers are compounded and manipulated with a view of correcting this defect. They are mixed with some of the semi-transparent black earths to improve the tone and hide the reddishness of it as far as possible. While the compounding kills to some degree the redness of the umber, it does not entirely do so, and the addition of the black earths renders the tone muddy, and there is no clearness in them. The eye in most instances is sufficient to detect the imposition.

Burnt umber is used for all kinds of painting, and for the same purposes enumerated under the heading of raw umber. It makes a different order of tints of drabs and browns with the white bases, and can be associated with any of the other permanent pigments for the production of an innumerable variety of tints. Some painters have complained of the tints made from it with white lead as not being permanent. All pigments which contain oxide of iron in its natural state, usually have it in an hydrate form, and after calcination and constant exposure

there seems to be a slight return toward the natural condition previous to calcination; but this in a good umber is so very slight, that it would hardly be noticeable. The probability is that in the case of many of these complaints, the trouble was in the sinking of the oil and the apparent bleaching out of the lead. If linseed oil is applied over the faded part, the color will be restored to its original tint without loss of intensity. If the color is at fault, the applying of the oil will not restore the color, if that is gone. If one has such a trouble, it will be an easy matter to test it, and to ascertain by the above simple test where the fault lies.

There is such a thing as false economy; and that it certainly is, to buy an inferior quality of burnt umber. Much of the disappointment of painters in its use, arises from the employment of poor or doctored umbers.

SIENNAS

General Characteristics and History

Siennas — earths, for earth they are — are really a species of ochers and they do not differ greatly from them in their chief constituents. It has already been explained that many of the American ochers border upon the threshold of the siennas, and on this account it is sometimes very difficult to place them properly. The more transparent of them are usually sold as siennas.

Siennas, then, may be said to be transparent ocher of a brownish yellow tone. The finest qualities come from Italy, and, as their name, *Terra di Sienna*, indicates, are mined near the city of Sienna. But it is found elsewhere and of even better quality. The headquarters for

the distribution of the siennas in Italy is the city of Leghorn, and excellent beds of it are found in the immediate vicinity.

Chemistry

Siennas usually contain a larger percentage of ferric-oxide hydrate than do most of the European ochers proper, as the following analysis by C. H. Hurst indicates:

Hygroscopic water	8.2 to 17.5
Combined water	9.0 to 12.4
Manganese dioxide	0.6 to 1.5
Iron oxide (Fe_2O_3)	45.8 to 59.7
Silica	5.0 to 17.4

The above analysis covers the extremes, and variations will be found between the two.

Siennas are mined as other ochers are, and they have to be purified in the same way and manner as was fully indicated under that heading.

Properties and Uses

It is an easy matter to judge of the value of a sienna. If the sample to be examined is ground in oil, it should be spread upon a clean piece of glass in the same manner as for the umbers. After smoothing it over with the palette knife, one can judge of its clearness of tone and transparency by holding it between the eye and the light. Spreading with a surplus of oil will indicate the fineness of the grinding. If it has been properly ground it will be entirely free from specks or cloudiness, and it should appear completely absorbed by the oil. In the raw sienna, the tone should be a clear, subdued yellow, with just the slightest tinge of brown showing in it.

RAW SIENNA

Properties and Uses

Raw sienna is useful for a wide range of work, covering all the various branches of painting.

To the graining trade especially it is most indispensable; it could not be replaced with anything else.

The general house painter and the decorators depend upon it for the making of many beautiful cream tints in linseed oil, with the usual white bases or with whiting, etc., for distemper wall work or decorations.

Raw siennas are absolutely permanent. No change can take place in them when they are used alone and when mixed with other pigments; the only changes are such as take place in the pigments with which they are mixed and which are inherent to them, and, of course, such changes as are natural to the vehicles used in their application.

BURNT SIENNA

Properties and Uses

As the name indicates, this is the raw sienna after it has been *calcined*. The roasting or burning produces a very great change in the color of the raw sienna. It transforms its color from a yellowish brown to a beautiful subdued red-brown of great richness. So rich is it, indeed, in some of the better samples, as to create the impression in the beholder's mind that possibly it might have been tampered with, and had been "fixed up" and enriched by the addition of a lake. Yet in all the best and finest qualities of that pigment, this richness is inherent in the sienna itself and this tone is permanent, which it would not be were it put there by *laking* it up.

It is the practice of some color makers to use two different kinds of burnt siennas in their grindings. They choose among the samples of native siennas such as are very strong in coloring matter, and these they grind for the general trade, who use siennas mainly in the making of tints with white lead or white zinc in oil or with whitening in distemper. A word must be put in here regarding the making of tints with burnt siennas. Even the very best of them do not give as good satisfaction as might be expected from such fine pigments. The range of tints made from burnt sienna and the white bases are at best but indifferent, and as good or better can be made from the use of Venetian red ocher with the faint addition of black, at a less cost for material and with equally as good results as far as durability goes. The grinders, being aware of this peculiarity, therefore, use an indifferently-toned burnt sienna which is strong in coloring matter but deficient in richness; and as this richness is only apparent when the burnt sienna is used as a self color, it does not matter. This is sometimes labeled as *House Painters' Burnt Sienna* to distinguish it from the other grinding which they make of the rich transparent kind, and which is labeled by them as *Grainers' Burnt Sienna*. This is intended for use as a self color, and, as such, all the richness is appreciated fully, and by none more than the grainers and decorators; this is selected for the very purpose for which the grainers need them, transparency, richness and clearness, associated with impalpably fine grinding. These are not strong as a rule, and, in testing a sienna for values, the mere strength should never be taken into consideration in estimating the higher grades.

Volumes might be written, but all would not be said about the uses and abuses of the siennas. They have many friends among all classes of painters and artists,

and the few who have any trouble with them will find that they themselves are to be blamed for having used them for purposes and under circumstances where they should not have been employed.

VAN DYKE BROWN

Provenance and Preparation

Van Dyke brown is a pigment of bituminous character, and is usually found in or near bogs. Many theories have been advanced as to what it really is. Some suppose it to be a form of lignite, resulting from the decomposition of vegetation. However that may be, it contains more or less bitumen. It is found in England and Ireland, but the best that is upon the market is that which is imported from Cassel, in Germany.

Vandyke brown is known as *cassel earth* in many parts of the world. It contains iron, and should be calcined and well cleaned of its impurities before grinding.

Properties and Uses

Vandyke brown is used by grainers in both oil and in distemper, and by some in the coloring of fillers for furniture factories. It is not a permanent pigment, and becomes lighter and redder by exposure to sunlight. It is a very powerful anti-drier in linseed oil. It therefore requires the greatest of care in use. In tone it has a peculiarly pleasing walnut brown, different from that of any other pigment. It is very transparent, and that would make it an ideal grainer's pigment.

But, on account of its defects, it is being gradually replaced by burnt umber, tinged to imitate its tone and to correspond so nearly to it as to deceive the casual observer.

It is hardly necessary to observe that tints made from it with the whites are subject to fade from the same causes which affect the color when it is used by itself, and as all the tints which can be made from it are readily reproduced by using burnt umber, black and blue, and that when they are so made they are permanent, the use of vandyke brown for the making of tints has nearly become obsolete, and is hardly ever resorted to except by novices.

The grainers will hardly be willing to part with it for distemper work in the graining of walnut. It is better suited to that than any other, as on account of its transparency there is a depth of tone shown under varnish, which is unattainable by the use of any brown pigment.

METALLIC BROWNS

Preparation and Manufacture

Under that generic appellation, some excellent pigments are produced in the United States. All are native iron ores or highly ferruginous earths mined in all parts of the country, but especially in the Appalachian system of mountains of the eastern seaboard, extending from Pennsylvania in the north to Alabama in the south. The Rocky Mountain system contains also some fine samples of these, and here and there are found outcrops of them in the great valley between the two. This ore or iron earth is calcined by roasting, pulverized, levigated, dried and barreled, and is then ready for market. There is a great deal of variation in its character and in the amount of ferric-oxide coloring matter it contains.

The samples vary in the percentage of color contained to a greater degree than any of the earth colors, ranging from nearly nothing to 90 per cent of iron oxide. The

bases upon which the coloring iron oxide rests vary almost as much as that. Most of these browns contain so much coloring matter that the color itself is really the base, and the other matter found with it is of so small a percentage that its presence is merely to be considered incidental.

Properties and Uses

The metallic browns mix readily and absorb a fair quantity of linseed oil as a rule, the nature of the accompanying base having something to do with that. They range in tint from bright red brown to dark purple, and all sorts of intermediate shades between these extremes.

Metallic browns are extensively used for roof and barn painting, the painting of iron bridges, structural iron and steel, freight cars, etc.; in short, for nearly everything where a good substantial covering is required, where the main consideration is good service, but does not lie in the beauty of the finish.

They are also useful in the making of certain brown tints, either alone or as adjuncts to other pigments. The manufacturers of mixed paints use tons in their better grades either as bases for the darker tints or as tinting colors in the making of certain shades.

They are fairly permanent, showing little tendency to change, other than that pertaining to all iron oxide pigments — that of darkening by age — but linseed oil probably is the cause of as much of it as the pigment. No one should hesitate to use them for all kinds of work where a cheap, but dependable paint of no special beauty is required. They can be much improved in looks by combining with some of the brighter pigments.

They possess great covering properties, and one coat, even when thinned excessively with linseed oil, will usually cover solid any other color over which it is applied.

It commonly comes in the dry state packed in barrels of 300 pounds capacity. It is ground in oil also, and put up in the familiar tin packages and wooden kegs and barrels.

SPANISH BROWN

Properties and Uses

To all intents and purposes, this pigment might have been included with the mineral browns. As a distinctive appellation to designate a shade of brown color, it has no signification whatever to-day, whatever it may have had in that regard in the past. It is still known and sold under that name in many localities, but this is chiefly confined to Pennsylvania, Maryland, and the eastern and southern seaboard. Since the advent of the metallic browns, the name has become a memory with the older painters of the middle and western states, and is almost unknown to the younger generation of the craft.

All that can be said for it is that under the name, anything, or rather any kind of a dirty red brown earth, is usually sold as such, and the grades of metallic browns, which are sometimes sold as *Spanish Brown*, are of a lower order than are those sold under other names.

The use of the name should be discouraged as it is not best to have confusing elements. The nomenclature of pigments is complex enough to suit the most fastidious, and the purpose should be to keep it as simple as possible.

Other substances have been and are listed as brown pigments by certain houses catering to the artist's trade.

None of these have any special virtues worth noticing here and they are passed by. Most of them are but variations of some of those that are listed and described—such as bister and asphaltum — and are so undesirable, even for artists' use, that they, as well as the painters and decorators, might profitably learn to dispense with them as pigments, whatever value they may have in other respects.

CHAPTER XVI

BLACK PIGMENTS

LAMP BLACK

Chemistry and Manufacture

THERE cannot possibly be any hesitation or uncertainty experienced in selecting a black for first place on the list. This place belongs by common consent to *lamp black*. Although it is far from being the *blackest black*, or the purest toned black, it must be accorded first place, because of its greater usefulness over any of the other blacks.

Lamp black is a *soot*, produced by the incomplete combustion of resins, resinous woods, fats and fatty oils, paraffin and paraffin oils. These substances are burned with an insufficient supply of air, so that a considerable portion of the carbon they contain may be deposited as soot. The soot thus produced is far from being pure carbon, and, of necessity, much of the tarry products of imperfect production or destructive distillation are present in combination with it. These foreign admixtures give it the undesirable tones to be found in the inferior grades. Owing to their greasiness it is almost impossible to use them with linseed oil, as they are highly non-drying. Much of the impurity is deposited in or near the first receiving chamber, and the lamp black which is deposited the farthest away from where the substances are burned is the freest from impurities.

Calcination in an intense red heat burns up most of these non-drying oils and tarry products and then the lamp black is perfect. The first that is deposited is usually sold dry in the well-known small paper cones, and these bear no manufacturers' names. The rest is selected and graded according to its color and freedom of foreign matter. Usually there are three qualities selected besides the inferior one mentioned.

Some substances produce a better lamp black than others, and there are many little tricks of trade and manipulations known to and employed by certain manufacturers that are probably not known to others, as some do produce much better blacks from the same material.

Properties and Uses

Lamp black being nearly pure carbon is inalterable and is absolutely permanent and unchangeable.

The oft-cited signboard left and forgotten for generations in the back yard, and which has had its ground coats of white paint eaten away, and where the board itself is disappearing in the shape of lint picked up by birds, for the making of their nests, until the black lettering painted upon it originally, stands out as if carved out from the wood, in bold relief among the general decadence surrounding it, is a very good illustration of its permanency and preserving powers. Such old-time signboards may be found and noticed in any neighborhood.

Lamp black seems to act as a preservative from decay to the linseed oil and to help it postpone indefinitely the day when it should go the way of all flesh and perish.

One of the chief uses of lamp black is in the making of gray tints with white lead and zinc white, as the tints so made are free from the brown gray tones so objection-

able in some of the bone blacks, and especially of the red brown grays produced by the use of gas or carbon blacks. The lamp blacks give a clear-toned clean bluish gray, or rather the cast of it, as it is not a blue tone at all. These grays are distinctively its property, and through them may be distinguished its purity and quality. Lamp black is very strong in coloring matter, and its strength makes it an economical tinting agent.

For solid painting, where an intense black is required, it may not be as good as some of the bone blacks, but when any solid black painting is done, where intensity of tone is not of the first importance, its use will prove much the most satisfactory.

On account of the lightness of its weight and consequent bulkiness, it is very difficult to mix it with water. It floats, and no amount of ducking it under will make it stay down. When it is wanted for use in distemper, it should first be mixed to a stiff paste with vinegar, in which liquid it is not so refractory as it is in water. It can afterwards be thinned with glue water and used for the making of tints or by itself as desired.

From its great bulk it may be well surmised that it absorbs great quantities of linseed oil, and it surely does. In fact, it absorbs more than any of the other pigments. Owing to the great quantity of oil it absorbs, many grinders cannot resist the temptation to add some barytes to it. This can be done without the use of any additional oil, but this can be detected readily by the smaller-sized packages required to pack any given weight of it. The smarter ones put some bulky stuff along with it, and then the eye will not suffice, and a scale test will be required to determine its purity. There should be but very little difference between two samples of equal purity, as to their strength. However, one may have

been ground with more oil than another, or have lain upon the shelves until the oil has risen; therefore the samples should be placed upon a piece of blotting paper and the oil extracted from them so all may be used in the same form of a very stiff paste before weighing them. A good lamp black, even the very best, is never of a jet tone, and alongside of a good bone black it looks grayish black. Therefore, if it looks blacker than it should to a person in the habit of using lamp black, it is possible and nearly certain that it has been bolstered up with an admixture of gas black.

It is, or rather has been, the habit of some grinders of small reputation as to the class of colors they put out, to use a cheap or poor lamp black and to color it up with carbon black, so that it will pass muster. If this is suspected, it can be quickly determined by simply using a little white lead which should make a gray tint of it. If it produces the usual gray without any brownish hue to it, the lamp black is all right; if, however, the tint so made does show a brownish tone, a solemn oath can be taken, without fear of perjuring one's self, that the black has been tampered with and that the tampering agent is gas or carbon black. Any court would clear one of perjury after reading the evidence presented by a chemical analysis and the sworn statements of its examination by experts.

GAS OR CARBON BLACK

Properties and Uses

Gas or Carbon black, as it is indifferently called, is really only a variety of lamp black. It is produced in a similar manner as that pigment, but with this difference, that it is made exclusively from the incomplete combus-

tion of natural gas. It is therefore the soot produced by that commodity.

It is readily distinguishable from true lamp black in that it is by far the blacker looking black of the two, and that for jettiness, true lamp black alongside of it — is not in it.

While the tone of this black is very superior to lamp black, it possesses some very grave defects that have in a great measure prevented its adoption for general use. Should these defects ever be satisfactorily overcome, it then would become *the* black, for solid painting at least.

One of its principal faults is that when mixed with linseed oil, it *livers* it. In trade parlance, *livering* means that peculiar action some pigments have of turning the oil into a jelly-like condition; it thickens to such an extent that it cannot be used with the brush in painting.

The livering of gas black is prevented to a certain extent by compounding it with other pigments, and the best use that is made of carbon black is when it is associated with other blacks. The sign writer's so-called blacks are usually compounded from true lamp black and carbon blacks.

Its one other great fault has been noted already. It makes very poor grays, and, while a true lamp black can be improved with it in self color for solid black painting, yet on account of its poorness for tints it must be considered as an adulterant, as the innocent purchaser might want it for the making of tints, and in that case he is simply swindled. Why not sell each for what it is and let the painters do their own compounding? In the case of a sign-writer's black, it is different. Then it is not passed as a lamp black or any particular black, and the name itself indicates that it is to be used for solid

painting. If one uses it for making tints, he does so at his own risk, because the label does not convey any idea of its fitness for it.

Some manufacturers have put out carbon blacks under various names, but, for probably good reasons, none of them have become very popular so far; and while they seem to have stopped the livering of it, this may have been done at the expense of another quality of the pigment which has been disturbed by the addition of the preventive. Be that as it may, it certainly is a fine-looking black, and it is a pity that it does not possess the other good qualities of lamp black; if it did — that would not be in it.

Its best use has been upon ship work. Steamships painted with it look immensely better than when painted with ordinary lamp black. Nearly all the transatlantic lines now use it regularly for that purpose.

IVORY BLACK — DROP BLACK — COACH BLACK

Manufacture and Preparation

Ivory black, drop black and *coach black* form a trinity of blacks, but in reality are but one and the same black, with the exception hereafter named. So it is thought best to bunch them under one head.

The above blacks are all *bone black*. The bone black selected for their manufacture should be from the hardest and jettiest samples.

Bone black would be too common a name for these blacks, and probably for that reason it has been dubbed *ivory black*. It stands to reason that as there is scarcely enough ivory in existence to supply the demand for ivory black in the United States alone for a single year, let alone the demands that exist for it in Europe and all

civilized countries, the black that is sold under that name cannot be *it*.

Bone black is properly *animal charcoal*. This is made upon the same principle as wood charcoal. The bones are placed in a retort and are calcined in a hot furnace where atmospheric air is excluded. The better qualities of bone black are made from selected hard bones such as animals' teeth, etc. The resulting bone charcoal is pulverized before placing upon the market.

The variety of it known as *drop black* is the same black made into little cones of the shape and size of a large chocolate drop — in which form it was more familiar to old-time painters than to those of the present day. These little cones resulted from the bone black, which, after grinding, had been mixed with water (holding a slight adhesive in solution) into a stiff paste, and the little dabs of it placed upon trays to dry were the cones or drops which gave the bone black the name it still carries to-day — minus the drops. The drops were placed upon a marble slab and ground with oil with a muller after first crushing it. That made life a burden, or at least the painters of that period thought so, for, if they had a large job upon which it had to be used, it meant the spending of their evenings till ten or eleven o'clock grinding away for dear life.

Ivory and drop black have a small admixture of Prussian blue added to them to correct any brownish tone. Coach black has no blue added to its bone black composition. That is all the difference that there is between them. A color manufacturer, to whom the writer had once made the same criticism, laughingly replied that there was still another difference which had been forgotten, and when asked what this was replied, "*The different labels upon the cans.*"

The ivory blacks are used in oil, japan, varnish and water. They are good blacks when well made and are used in all mediums. As an oil color they are usually too transparent to use for solid painting, except as a last coat over a previous solid one of lamp black, where that color is insufficiently black to suit. They are excellent in distemper, and the grainers find them advantageous for their work in either distemper or oil, for the working in of dark veins, knots or shades, for which they are admirably adapted on account of their transparency.

In japan they are invaluable to the car and carriage painters. The carriage manufacturers use enormous quantities of it in the painting of buggies, surreys, coaches, etc., not only for the solid black painting, but for the mixing of the numberless dark greens used by the trade in the painting of everything that runs on wheels.

Formerly every carriage shop used to buy the various colors ground separately and mix the various shades in the shop as wanted, but now few of them do so, and these various dark greens under an array of magnificent names are compounded and made to match at color works where the proper facilities exist for handling them to the best advantage and with the most assurance of duplicating them *semper idem*. The multitude of names given special blacks, or rather grindings of them, is bewildering, as every manufacturer has a long list of his own which he tries to make as puzzling as he can, and besides that he has a number of special-formula blacks which he grinds for certain carriage factories, each having a special name. One may as well look for a needle in a haystack as to try to understand the average coach color list. About the only indication of quality is the net price, and frequently even that — is not.

All this confusion about an article which, when let alone, is purely *bone black*, looks to the disinterested spectator as if there might be some money in it, or it could not be kept up. If goods were simply labeled and sold for what they were, as first, second, third, or fourth quality, or as compounds of this and that, then it would be easy for one to know what he was buying; while, if the average buyer can be puzzled, there exists a chance to demand an undue profit.

The ivory blacks are also used largely by the japanning plants, enameling works of all kinds, bicycle factories, etc., they are very permanent under any and all situations.

CHARCOAL BLACK, OR BLUE BLACK

Preparation, Properties, and Uses

As the name of this pigment indicates, or at least one of the two names under which it is known in the United States does give an inkling of its origin. Charcoal black is a product due to combustion, and, like ivory black, it is also a charcoal, but there is no bone or any sort of animal matter in its composition. It is a wood charcoal and of vegetable origin.

The wood used in the making of it has a great deal to do with its quality. This wood should be entirely free from resinous matter. Some of the best of it is produced by the calcination in a close vessel at a high heat of peach and plum pits, cocoanut shells, cork waste, grape-vine cuttings, etc., the powdered charcoal of which forms the *blue black* of commerce.

It is, of course, essential in a good black that the calcination should be thoroughly done, so that the product may be free from any tarry or empyreumatic substances.

Blue black is unchangeable and entirely reliable in distemper work, and for that purpose is the black *par excellence*. Decorators and artists use it mostly, and that only in water colors. It is also used occasionally by some grainers.

In oil it has little if any body, and for that reason is seldom, if ever, used but as a glazing color, or for shading, and obtaining certain effects of depth unattainable with body pigments.

GRAPHITE, BLACK LEAD, OR PLUMBAGO

Production and Preparation

Graphite is the name under which this substance is best known as a pigment in the United States, and is a mineral carbon of a peculiar atomic formation. It is found in all parts of the known world with considerable difference in its quality, sometimes varying a good deal in the same ledge or vein.

That found in the Ural Mountains in Russia is the best of any mined in the Old World. Mexico produces the best that has been found so far in the New World. There is much of it mined in the United States, especially in New England, and it exists in New York State in the Lake Champlain region. It is seldom found in a state of entire purity, and calcination is the means usually employed to free it from impurities. The ashes of these are removed by levigation. After repeated washings, it should be digested with a strong solution of hydrochloric acid to remove any iron or alumina. After another levigating it is washed in a leaden vessel with hydrofluoric acid to remove the silica. After another thorough washing and grinding to reduce it to a fine powder, it is ready for use.

For distemper work it can be relied upon never to change. It is also permanent in oil, and when ground in that media it is of a dark slate color. It is an excellent iron paint, and is now extensively used for that purpose and as a paint for tin roofs. The dullness of its color is against it for anything but utilitarian purposes.

One great fault with it is that it shows markings readily, and a surface painted with it soon resembles a huge slate upon which everything that touches it with a little force, leaves its mark; unfortunately, unlike a slate, it cannot be sponged off.

There are a number of other black and semi-black pigments that might be added to the above list, but they are mostly obsolete, or of such a nature that they do not deserve notice. For instance, certain black or semi-black natural earths sometimes listed in catalogues as *Mineral Blacks* have never had any standing, nor have they ever received the recognition of the paint trade. They have mainly served the purpose of swelling the lists of a few paint grinders who may possibly have local trade in them for special purposes to which they may be adapted or used through ignorance of better.

Such blacks as India ink, which are principally special preparations of lamp black, do not come within the scope of this treatise.

The above comprises all the useful pigments. There are many compounds that are palmed off upon the public as pigments which will be vainly looked for here. Such have no more legitimate right to the name than would have any others of the thousands of tints made by the combination of true pigments. For instance, the stuff sold under the name of *Gray Ocher*, is not an ocher at all, and is a poor compound of shale or soft, crushed stone.

CHAPTER XVII

A TABLE OF SYNONYMS

No little confusion exists in the minds of many men, as to what is the right or proper name for certain pigments. When they happen to know a pigment by a given name, and it happens that this pigment is offered them by a dealer or is listed in a catalogue under another title, they are deterred from using it, as they cannot recognize it under its other name, and they suppose it to be entirely different from the one they want.

It is deplorable that there is no universally acknowledged nomenclature for pigments that would be recognized in all languages all over the world, or even an acknowledged nomenclature for the English speaking nations.

Custom in the United States is beginning to fix definite meanings to certain designations, whereby a few of the pigments and their different qualities may be known, but the work is far from complete and from being universally acknowledged even by our nation alone. So in Canada, Australia, New Zealand, the British Isles, where trade connections are not very close with us, the variations are bound to be greater than the ones which exist here where the usages of the paint trade have established a quasi-uniformity in a few of the leading pigments at least.

The names which have been adopted in this treatise and which have been given to the various pigments, are

those under which they are principally known and sold in the United States.

In the following tables the name adopted as standard in the preceding chapters for each pigment will be given preference. It will be placed in the left column. The synonyms under which the pigment is also known will be found in the column upon the right, and all bracketed together when more than one is used.

Thus any one seeking information concerning a pigment which he knows under another name than that which is given it in the treatise, can readily find it by looking for it in the right column of the group of colors to which it belongs, then, having found it, look at the left column, where he will find the name adopted for that same color, under which name he will find the description he seeks.

To facilitate the finding of the names, the same classification and grouping have been followed as in the description given the pigments. This renders the finding of any certain color's names an easy task.

TABLE OF SYNONYMS

The White Pigments

White lead	{ Flake white. Cremnitz white. Silver white, or Blanc d'argent. Cerusa or ceruse. Cremser weiss (Ger.). Blanc de plomb (Fr.). Chinese white. Oxide of zinc. Zinc weiss (Ger.). Blanc de zinc (Fr.). Carbonate of lime. Spanish white. Paris white.
Zinc white	
Whiting	

Kaolin	China clay.
Gypsum	Sulphate of lime.
White silicate	Silver white. Powdered silica.
	Barytes.
	Sulphate of barium.
	Floated barytes.
Baryta white	Heavy spar. Permanent white. Permanent weiss (Ger.). Blanc fixe (Fr.).

The Yellow Pigments

Ocher	Yellow ocher. French ocher. Roman ocher. Mineral yellow. Brown ocher. American ocher. Oxford ocher. Mars yellow. Mars orange. Artificial ocher. Gelben ocher (Ger.). Mars gelb (Ger.). Ochre jaune (Fr.). Jaune de Mars (Fr.).
Chrome yellow	Chrome. Chromate of lead. Canary chrome yellow. Lemon chrome yellow. Orange chrome yellow. Crom gelb (Ger.). Chrome jaune (Fr.).
Baryta lemon yellow	Baryta yellow. Barium chromate. Yellow ultramarine. Permanent yellow.
Gamboge	Gomme gutte.
Aureolin	Cobalt yellow. Kobalt gelb (Ger.). Jaune de cobalt (Fr.).
Indian yellow	Piuri. Puree. Peori. Indisch gelb (Ger.). Jaune Indien (Fr.).

Naples yellow	{ Giallo di Napoli (It.). Neapel gelb (Ger.). Jaune de Naples (Fr.). Jaune d'antimoine (Fr.).
Dutch pink	{ Yellow lake. Brown pink. Citrine lake. Yellow madder. Italian pink. Quercitron lake. Dunkel gelb lack (Ger.). Laque brun jaune (Fr.).
King's yellow	{ Orpiment. Konigs gelb (Ger.). Jaune royal (Fr.).
Cadmium yellow	{ Orient yellow. Aurora yellow. Orange cadmium. Sulphide of cadmium. Cadmium gelb (Ger.). Jaune de cadmium (Fr.). Jaune brilliant (Fr.).

The Red Pigments

Vermilion	{ Cinnabar. English vermillion. Chinese vermillion. Zunsober (Ger.). Vermillon (Fr.).
Vermilions Reds or Imitation Vermilions	{ Sold under a multitude of pro- prietary names.
American vermillion	Chromate of lead.
Venetian red	{ Rouge. Crocus. Colcothar. Caput mortuum vitrioli. Burnt ocher. Sinoper (Ger.). Rouge de Venise (Fr.). Ochre rouge (Fr.).
Indian red	{ Persian red. Indian red ocher. Indische roth (Ger.). Rouge d'Inde (Fr.).

Madder lakes	{ Pink madder lake. Rose madder lake. Madder carmine. Madder red. Rubens madder. Madder purple. Madder lake. Madder brown. Krapp lack (Ger.). Carmin de Garance (Fr.) Laque de Garance (Fr.).
Indian lake	{ Lac lake. Lack lack (Ger.). Laque d'Inde (Fr.).
Carmine	{ Crimson lake. Purple lake. Carmin lack (Ger.). Carmin (Fr.) Laque Cramoisi (Fr.).
Red ochre	{ Red hematite. Red iron ore. Scarlet ocher. Red chalk. Ruddle. Terra rosa. Miltos. Rubrica. Sinopis. Sinoper. Ochre roth (Ger.). Ochre rouge (Fr.).
Red lead	{ Minium Monium rubrum

The Green Pigments

Chrome yellow	{ Extra light chrome green. Light chrome green. Medium chrome green. Dark chrome green, and a host of proprietary names.
Cobalt green	{ Zinc green. Rinkman's green. Kobalt grün (Ger.). Vert de cobalt (Fr.). Vert de zinc (Fr.).

Viridian	{ Emerald oxide of chromium. Mittler's grün (Ger.). Vert panettier (Fr.). Vert de Guimet (Fr.). Vert emeraude (Fr.).
Terre verte	{ Green earth. Grün erde (Ger.). Terre de Véronne (Fr.). Terra verde (Ital.).
Green oxide of chromium . . .	{ Chromium sesquioxide. Opaque oxide of chromium. Grünes chromoxyd (Ger.). Vert de chrome (Fr.).
Malachite	{ Green verditer. Green bice. Mountain green. Green carbonate of copper. Berg grün (Ger.). Vert de Montaigne (Fr.).
Paris green	{ Emerald green. Cupric aceto arsenite. Schweinfurts grün (Ger.). Vert Paul Verone (Fr.).
Scheele's green	{ Cupric arsenite. Swedish green. Mittis green. Scheele's grün (Ger.). Vert de Scheele (Fr.).
Verdigris	{ Basic copper acetate. Grünspan (Ger.). Vert de gris (Fr.). Vert de Montpellier (Fr.).

The Blue Pigments

Ultramarine blue	{ New blue. French blue. Permanent blue. Gmelin's blue. Guimet's blue. Lapis lazuli blau (Ger.). Lasurestein blau (Ger.). Bleu d'azur (Fr.). Bleu d'outremer (Fr.).
Chinese blue	Soluble blue.

Prussian blue	{ Turner's blue. Antwerp blue. Berlin blue. Prussiate of iron. Chinese blue. Saxon blue. Pariser blau (Ger.). Bleu de Berlin (Fr.).
Cobalt blue	{ Kobalt blau (Ger.). Bleu de cobalt (Fr.). Bleu de Thenard (Fr.).
Ceruleum	{ Coelin. Cerulian. Cerulean blue. Coelin blau (Ger.). Blue celeste (Fr.).
Chessylite	{ Blue verditer. Bice. Mountain blue. Azurite. Berg blau (Ger.). Cendres bleus (Fr.).
Smalt	{ Royal blue. Dumont's blue. Zaffre. Smalte (Ger.). Bleu de smalte (Fr.).

The Brown Pigments

Raw and burnt umber	{ English umber. American umber. Levant umber. Turkish umber. Cyprus umber. Umbräun (Ger.). Terre d'ombre (Fr.). Terra ombra (Ital.).
Raw and burnt sienna	{ Italian sienna. American sienna. Siena erde (Ger.). Terre de sienne (Fr.). Terra di sienna (Ital.).

Vandyke brown	{ Cologne earth. Cassel earth. Collen earth. Cassel erde (Ger.). Brun de Vandyke (Fr.).
-------------------------	---

The Black Pigments

Lamp black	{ Russ (Ger.). Noir de fumée (Fr.).
----------------------	--

Ivory black	{ Drop black. Coach black, and in japan or varnish a host of proprietary names. Elfenbein schwartz (Ger.). Noir d'ivoire (Fr.).
-----------------------	--

Gas black	{ Carbon black; in oil or japan and a host of proprietary names.
---------------------	---

Charcoal black	{ Blue black. Vine black. Frankfort black. Frankfurter schwartz (Ger.). Noir de vigne (Fr.).
--------------------------	--

Graphite	{ Black lead. Plumbago.
--------------------	----------------------------

As many of the artist's tube colors are imported from Germany and France, such as De La Croix, etc., it was thought best to give the names of most pigments in the languages of those countries as the names upon the labels are in those languages.

CHAPTER XVIII

VEHICLES USED IN MIXING PIGMENTS

THE FIXED OILS

PIGMENTS require various thinning liquids, so that they can be applied with a brush to the surfaces which they are to cover over. These liquids must possess binding qualities so that the pigments may be adhesively retained upon the surfaces.

Some of the *vehicles*, as these liquids are called, possess within themselves the requisite binding properties; others do not, and must be rendered adhesive by the addition of other substances which, when mixed intimately with them, make them artificially adhesive — as water, for instance, which is the vehicle used for distemper painting.

It is highly proper and even necessary that one should know something of what is required from the various vehicles used in painting, and why one is used for certain purposes in preference to another.

The one which is of the most importance in connection with outdoor painting, must possess some well-defined qualifications, as otherwise it would fail to do what is asked of it. It is an absolute necessity that it should contain within itself perfect adhesiveness, which will be referred to as binding quality, and that after it dries a smooth, waterproof surface may be obtained that will prevent moisture from penetrating into the pigment and thus affecting the surface which has been

painted. The pigments in a powdered condition are helpless to protect themselves, and none contain adhesive-ness to hold to the side of a building. It is the vehicle used in the mixing of the pigment which must be relied upon to do the binding.

Pigments indirectly affect the durability of the thinning liquids, and a few do so directly.

For outside painting, which is subject to all the inclemencies of the weather, — heat, moisture, and frost, — it is obvious that the binding vehicle must possess water-proofing qualities of a high order. It must harden into a solid mass, for otherwise the paint would be rubbed off or washed away by rain.

Nearly all oils are waterproof and will shed water; none mix readily with it; but only a few have the property of solidifying into a hard, waterproof mass, and the oils which possess this power are called *fixed oils*.

There are many trees and plants whose seeds give drying or fixed oils, such as the walnuts, hickories, pecans, flax, poppies, and others.

Flax and poppy are the only plant seeds the paint world need worry about. These are the two used for painting, which can be procured at a reasonable price in a commercial way. The main reason for this is that oils can be expressed from them much more cheaply than from any other known plant seeds. Flaxseed is most abundantly raised as a field crop, and its cost is low compared to that of any others, not excepting poppy seed. These two plants possess peculiarities of their own which make them more desirable than any other for the making of a paint oil.

Besides possessing the general characteristics which belong in common to all fixed oils, each of these (linseed and poppy seed) has its own which make them differ

from each other and from every other of the fixed oils as well. These peculiarities fit each one of these oils to be better adapted to a certain purpose than it is to others, and indicates which of the two it is best to use for certain conditions. While poppy-seed oil is superior to linseed oil for some painting (as for zinc white enameling), it is inferior to linseed oil (as flaxseed oil is universally known in English-speaking countries). This and the other very good reason that linseed oil is by far the cheaper of the two, are the main causes why poppy-seed oil is so seldom used in general painting. There can be no question as to which is entitled to head the list of useful vehicles.

LINSEED OIL

Manufacture

Linseed oil is expressed from common cultivated flax-seed (*Linum usitatissimum*). This is grown in all parts of the civilized world. It grows from almost the sub-arctic regions down to tropical countries, and even in these in elevated regions.

The process of extracting the oil from the seed is a very simple one, and once every little town or hamlet had its crushing mill and extracting presses. To-day in this business as well as in that of every other commercial commodity, the manufacture of linseed oil is in the hands of large concerns, and the small plants have gone out of the business.

The flaxseed is ground into meal, and this is either cold pressed or heated, and the oil pressed out of it by powerful hydraulic presses. The oil flows out, and the solid parts of the seed remain in what is well known as *linseed-oil cake*.

The cold-pressed oil is clearest, palest, and best; but as by that process it cannot be made to yield nearly so much

oil as when the flaxseed meal has been heated, that is very seldom practiced now. This is a pity, for cold-pressed linseed oil is superior for painting purposes, and is clearer, more fluid, and free from much deleterious matter which is extracted by the hot system.

There is still another system in use for extracting the oil from flaxseed, and a still greater percentage of oil is obtained from it than by the use of either the cold or hot system of pressing. This is known as the *percolation process*.

After the grinding of the flaxseed into meal, this is placed into a percolating tower running through the several stories of the factory building. When filled with flaxseed meal, this is saturated with benzine or naphtha, and more of that subtle fluid is poured upon the meal at the top of the tower. This is continued until all traces of oil have been dissolved and removed from the meal. The naphtha charged with the dissolved linseed oil runs downward to the bottom of the tower into a pipe, which conducts it to an apparatus where it is heated. The naphtha, being a very volatile oil, is evaporated at a comparatively low heat. These vapors are conducted to condensers, and the vapors soon condense into what they were originally — naphtha. This is used over and over again; there is but very little loss of it. The remaining oil is entirely freed from the naphtha by this heating, if it is properly managed. It is claimed by some that by this system, certain substances are dissolved which would remain undisturbed by pressure, and that the loss injures the durability of the linseed oil for outdoor work. This claim, however, may not be well founded, and may be due to prejudice or the self-interest of concerns that press oil. Some again claim that it is better. However, so many from all parts of the country claim differently,

that one should be slow in making the change from one to the other. Experiment with them side by side under varied conditions. This system has some good points in it. Naphtha does not dissolve moisture, and linseed oil thus made is as nearly free from it as it is possible for it to be, and this cannot be said of the heat-expressed oils. The real difference between the pressed oil obtained by heat and the percolated oil, cannot be so great as to deter any one from using either, but the chances are that the old-fashioned cold-pressed oil is the best.

Linseed oil made by whatever system, may vary a good deal in its quality from other causes than those pertaining to the system of extraction. It varies greatly accordingly as it is made from good or from bad flaxseed. That made from East Indies, imported flaxseed (better known as Calcutta seed, from the city from which it comes) is usually better than that obtained from American seed. Its product, sold as *Calcutta-seed oil*, is usually freer from moisture than that which is made from flaxseed of American or Russian origin. Varnish men who ought to be good judges of quality in linseed oil, prefer it to all others, in the preparation of varnishes, as they must have a dry oil, containing but little moisture. American flaxseed, when properly harvested, is as good as any in the world — but there is the trouble, it is not harvested properly. In America, flaxseed is harvested by machinery, the same as wheat. Owing to the ease with which it shells out when the sickle strikes the plant, the cutting cannot be delayed until the seed is ripe, as it would all shell out and fall to the ground; so the crop is cut down before it is ripe, just as the seed begins to change from the dough state and begins to harden. In that condition, it is saved without shelling — but it is far from

being fully ripe. In the East Indies, where labor is very cheap, it is pulled by hand, when the proper times comes, and thus they are able to secure it in the very best condition. This is impossible in America, hence American seed does not equal it.

So with poor seed to start with, and a larger quantity of oil expressed out of it than in the good old days of cold presses, there can be no wonder at the complaints that linseed oil does not wear as well to-day as it did in old times.

For good work, it would pay to use cold-pressed oil, even at an expense of several cents more per gallon. It would pay architects to specify it in their contracts, and property owners should be willing to foot the slight increase it would make in their painting bill, if they could only be made sure that they were getting it after specifying it and paying for it. But *quien sabe?*

Linseed oil, after it has been pressed, should be tanked for three or four months to allow it to deposit some of the foreign matter pressed out of the seed with the oil, and with which it is more or less charged. This will settle to the bottom of the tanks, and is called *linseed-oil foots*. It will do so naturally, if only time enough be given — but it is not allowed.

Manufacturers being human (in some ways) do not take kindly to the idea of having vast sums of money tied up for several months in a tank. They want to turn that money over and over before the oil would be fit to sell in the natural way it has of doing this work, so they artificially hasten this precipitation.

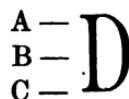
There are two ways of doing this; one is known as the alkaline process. As this is the poorer of the two, no time will be wasted upon it. The other is by trituration with sulphuric acid.

Sulphuric acid does not affect linseed oil injuriously, and it acts only upon the impurities which precipitate rapidly. The oil is then well washed with water by trituration until it is free from traces of acid, and is then considered fit for use. Varnish manufacturers who are most careful in the purchase of linseed oil usually still further refine the oil by repeated agitation of it with sulphuric acid; and the grinders of fine pigments requiring refined oil, use it also for the same purpose. With both of these sets of men, clearness and limpidity are of the first importance; but painters of the old school who can remember the time when they went to the town mill and bought cold-pressed oil settled in the old-fashioned way, and used it to mix their pigments with, claim that three coats of such oil and white lead would wear for years before it would commence to chalk. Now a like number of coats prepared in the old way, but with oil *such as it now is*, will appear as so much whitewash in the same number of years. It will require something else besides plausible talk to make them believe that the oil they buy to-day is half as good as the old-fashioned, cold-pressed, naturally settled oil made from pulled flax which it was possible for them to buy some seventy years ago.

Chemistry of Linseed Oil

Linseed oil is a complex product, and its drying or solidifying is due to its becoming oxidized. Condit says: "To understand the action that occurs when oil dries, we must know the composition of it. Linseed oil is composed of linolein, palmittin, and olein. To non-chemists, these words are mere names; but let us designate linolein by A, palmittin by B, and olein by C; now A the first is composed of linoleic acid and glycerine ether, B of palmitic acid and glycerine ether, and C of oleic acid

and glycerine ether. Glycerine ether is the base to which the other constituents are attached. Looking upon glycerine as D, we may represent the other constituents as allotted in this manner:



Chemically considered, these salts (A, B, and C) are susceptible of parting with their base glycerine (D) in favor of some base possessing a stronger affinity for oily acids."

The Drying of Linseed Oil

"This kind of decomposition in point of fact really takes place under proper conditions, and the resulting soap varies in its nature according to the base employed. Take an instance: Suppose you have rubbed some linseed oil on a sheet of glass or china (I mention these substances to preclude the idea of the absorbance of any part of the oil which would take place if wood, etc., were used) and it has sufficiently dried not to become sticky, and that when in that condition you wash it with a solution of soda in water, the soda dissolves the glycerine to unite with the oily acids (linoleic, palmitic, and oleic) and forms a soap, leaving the glycerine free. In other words, using the above formula: A, B, and C unite with the soda (or other alkali) and leave D a free agent. Now this D is soluble in water, consequently the soap which is formed (by the union of A, B, and C with the alkali) is also dissolved. This soap, by the way, is not like the ordinary hand soap, but is a frothy matter that gathers on the glass. Hence, by washing the oil with sufficient soda and water, every trace of oil is carried away from the glass."

The above explains what would take place if the oil were left in an undried state, and to some extent what does

take place when linseed oil is washed over with alkalies even when dry. It is the same action which takes place when the alkaline removers take off paint; but to return and find out how oil dries, Condit further says:

"In speaking of the drying of linseed oil merely a change from the liquid to the solid state is meant. Now the constituents of the four components of linseed oil consist of oxygen, hydrogen, and carbon in varying proportions; that is, linolein A, palmittin B, and olein C are all made up of the above elements, differing in proportion just as the letters A, B, and C are made up of straight lines and curves, differing, however, from each other in the totality.

"Now in the change from the fluid to the solid condition, *i.e.*, the drying process, oils suffer a slight loss of carbon and oxygen, but they gain about one tenth of their own weight in oxygen. It is by this union of oxygen with the component of linseed oil that they dry or harden. Put them out of the influence of this element and they remain fluid. Slow-drying oils lose least in weight; they contain more of the non-drying fats, and for that reason seem to gain more in weight (in time)."

The process of drying, while it is very simple, in theory at least, is most intricate, and would require too many explanations to follow it up in all its details, so it cannot be given here as fully as some might wish. To properly handle the subject would require a large volume, therefore a résumé is given below in short paragraphs, which contains the gist of the process; it, too, is from Condit:

"1. Linseed oil is composed of linolein drying oil, 80 parts; palmittin and olein non-drying oils, 20 parts, of which 8 parts are glycerine ether which flies away in the process of drying.

"2. Pure oil will not dry in darkness; and the greater the light, the more vigorous the drying.

"3. Heat is also a powerful drier of oil; oils heated for a short time continue to dry more rapidly for a long time after the heating.

"4. Drying appears to be the loss of glycerine ether and the gain of oxygen from the air, the glycerine appearing to be loosened from the oil acid as the oxygen unites with the oil, the result of the drying being a light varnish.

"5. Some of the non-drying oil acid also flies away in the drying, especially under the influence of direct sunlight or when the oil is heated; 100 parts of oil become 111 parts (more or less) heated; it loses 3 parts (more or less); net gain 8 parts.

"6. Most of the glycerine ether which is linked with the oil flies away in the drying.

"7. When oxygen combines with a drying oil — that is, a fixed oil — caoutchou or gluten is produced, which in reality is the hard, horny, elastic body that renders it 'dry.' It is the 'skin' that forms on top of a pot of paint when it has been left undisturbed for some time.

"8. The drying of oils appears to depend upon the presence of oxygen, which, by an incipient combustion of hydrogenous oils, fixes them. Whatever contributes oxygen is a drier, as is the case with pure air, sunshine, etc. So also the perfect oxides of metals, including even pure earths and alkalies in due proportion, dry oils; the best are those which contain oxygen in excess, such as litharge, sugar of lead, minium or red lead, the oxides of manganese, sulphate of zinc, white copperas and verdigris."

Properties and Uses

Raw linseed oil is penetrating and elastic, and after its oxidation or drying it remains as a waterproof rubber-

like substance, holding firmly whatever pigment it has been mixed with. Some pigments act chemically upon it, as, for instance, the lead salts, which have the property of turning it into a soap, which, however, is not a readily soluble one (after drying at least); the lead oxides are noted for this property, as red lead and litharge. Notwithstanding that a great deal has been said as to the beneficial influence exerted by the totally inert pigments — which in a measure is true — it is equally true that some very active ones, combining chemically with linseed oil, exert a very good influence over it, as occurs when red lead and linseed oil are combined, the resulting linoleate soap being, when dry, insoluble in water. It is not acted upon injuriously by that element, which is most destructive to linseed oil ordinarily. This, however, is not true of all active pigments, some of them exerting baneful influences upon linseed oil as they combine with it to form soluble soaps. Pigments containing lime in a caustic form are of that character.

The inert pigments naturally do not exert any influence upon it one way or another, and when linseed oil has been mixed with them no chemical action takes place; the drying and longevity of the oil remain the same, generally speaking, as if the pigments had not been added.

The above statement was purposely qualified by saying *generally speaking*, because in one way they do exert an influence which, while it is not chemical, is a mechanical one, in this way: Some pigments are very heavy and have no affinity for oil, and naturally take up but little when mixing them into a paint; others again are very light and take up large quantities. It is reasonable to suppose then that the pigment which has not taken up much oil will be a drag upon the oil, as a little of it is scattered over

a great quantity of pigment atoms, so that but an infinitesimal portion has to perform a duty that is above its strength, and so it is. Such pigments cannot be depended upon for outdoor work.

On the other hand, the pigment which holds up large quantities of oil mechanically prolongs its life.

Again, there is a class of pigments containing non-drying elements in their composition, which prevent the oil from drying, such, for instance, as uncalcined lamp black, vandyke brown, etc. These cannot be safely used without first preparing the oil, so that it shall contain sufficient drying energy to overcome their deficiencies. Artificial driers must be added to the oil to hasten its drying. Otherwise, these pigments exert a good influence upon the longevity of the oil, as they take up so much of it.

Linseed oil continues to absorb oxygen after, seemingly, it is as dry as it is possible for it to be, or long after it has ceased to feel tacky to the touch. The fact is that when it has reached that stage where no further oxidation takes place then its downward grade of decay may be said to have commenced.

Linseed oil, while it may not be as good as it was fifty years ago, when it was all cold pressed, is usually found pure, such as it is. It is, of course, possible for some of the dealers to practice the adulteration of it, but it is seldom that that occurs. Jobbers, in the past (a few of them), who did not care for reputation, did mix oils, but now such a thing is next to impossible. What with nearly every state having special laws, which no one would take any risk of infringing, and behind these Uncle Sam with his own strict laws to prevent fraud — the practice of adulterating linseed oil has about become obsolete.

Linseed oils are, however, imitated; but the imitations are sold as such. There can be no harm come of it, for no one is cheated. If a painter is foolish enough to believe all the stuff that smooth-tongued strangers tell him regarding the merits of nonpareil, indestructible enamelling liquid, in the way of throwing linseed oil in the shade, and supplanting it everywhere, he has a perfect right to believe and to give his money away for it. The law recognizes him as a free agent and will not forcibly keep him from flinging cash in the river, if he so wills. It takes money to buy experience, and with some men it only seems to last until the next deceiver comes around with another bait — 10 cents a gallon below the market on linseed oil!

Barnum said: "For every fool that dies, two are born." It must be true, or the concerns manufacturing dope oil could not flourish as they do.

Impurities, and Tests for Them

It is a very hard matter to determine impurities in linseed oil, and nothing short of an analysis made by an expert chemist used to that sort of work will be of any value. This work is intricate and expensive. But anyone can readily determine to his own satisfaction whether linseed oil is adulterated or not. At least, raw linseed oil can be so tested, but not the boiled. There is no test that one can make for himself that will do for that.

There are several tests. One, the most usual, is the nitric acid test. Although it is a simple one to make, it is apt to lead many into error, if they are unused to testing oils. To make the test: Take a bottle, or any other glass vessel, pour into it about equal parts of raw oil and nitric acid — one ounce of each is enough for the

purpose. Shake the bottle, so as to mix the oil and acid well together, and put it away to rest for a quarter of an hour. If the oil is pure, the nitric acid will settle at the bottom of the bottle, where it forms a distinct layer below the oil which floats on top. The nitric acid in a well-made oil will be found clear, but tinged to a light straw, from coloring matter extracted from the oil during the shaking; the oil itself in the upper layer will be found to have turned to a brownish color, but of a clear tone. If adulterated, the oil will be from dark brown to black and muddy, lumpy or "livered," according to the nature of the adulterant. The acid will be brownish, and often its limpidity even will be impaired; but not always so, this depending also upon the nature of the adulterating oils. It is impossible thus to determine the adulterant that requires a chemical analysis.

Then there is the specific gravity test, which is always satisfactory, as it is a very hard matter to adulterate oils so that this will not be greatly changed. It requires apparatus to make this test, but that is not very expensive: a suitable hydrometer, one that is adapted to oils or fats, with a thermometer, are all that will be needed. The oil should be poured into a vessel, which must be considerably deeper and wider than the hydrometer, which is dropped into it, and which must float clear of the sides and the bottom of the oil receptacle. The specific gravity of linseed oil is, say, 0.932 at 60° F. Now if the hydrometer is placed in the oil and the top of the bulb indicates .928 or .934, if the temperature of the oil is either above or below 60° F., a correction must be made for that, as the oil will show a lighter gravity if below the standard temperature and heavier if above. Deduct or add .00035 for each degree of variation in temperature either above or below the standard, and, if the oil is pure,

the total ought to be 0.932. If it varies very much, the oil is adulterated.

Then there is the flash test, but this is rather complicated and requires more apparatus to determine correctly. The two above-mentioned tests will be sufficient. Besides, the *nose* and the *eye* can be made nearly as efficient as any, at least for certain kinds of adulterants. Linseed oil has a smell all its own, and neutral oils can be readily detected by their odor with the nose, they have also a bluish fluorescent tone that the eye can readily note, so that, with the help of these organs, a double test can be made, and one or the other will be apt to uncover the adulteration. The nose will also detect animal or fish oils, which may be used in adulterating; however, the chances are that it will be hard to find any as long as they stay above the cost of linseed oil.

BOILED OIL

As it has already been stated the heating of linseed oil renders it more drying. When it is boiled at a great heat along with some of the oxides of lead or manganese it is rendered thereby still more drying.

For mixing with some of the non-drying pigments, its use is imperatively demanded, at least for the grinding of them into pastes. Boiled oil is less elastic than raw oil, and, being darker, it tinges the white pigments and some of the light tints to an undesirable degree. It is also much less elastic than raw oil and less penetrating, therefore it should never be used for priming purposes. It partakes of the nature of a varnish, and dries upon the surface with but little penetration.

It is therefore better adapted for interior painting than it is for that of outside work. Its use is indicated, how-

ever, for many purposes where penetration and elasticity are not of prime importance.

Adulteration

Under the heading of raw oil, it was said that all tests which were indicated for that were useless when applied to boiled oil, and so they are. It requires an expensive chemical analysis. Unless, of course, that the adulterating has been so carelessly done that the nose and eye can be utilized to ferret it out, as is the case when neutral oils have been added.

The most frequent adulteration, if adulteration it be, is in many dealers taking, say, one barrel of raw linseed oil pouring the contents of it into the boiled oil tank and adding from five to ten gallons of some cheap benzine manganese drier. Boiled oil thus prepared is called *bung hole boiled oil*. It is simply raw oil with probably a bigger dose of liquid drier than would have been the case if the painter had added it himself.

POPPY SEED OIL

Properties and Uses

As the name implies, this excellent paint oil is produced from the seed of the poppy plant — opium poppy, or *papaver somniferum*. It is nearly colorless and very clear, so these qualities render it of great value for the mixing of white pigments or for that of tender light tints. For China finish or interior enameling, for instance, it is invaluable. In this connection it should be used with zinc white in preference to linseed oil, which has the property of darkening the more quickly that it is shut away from the sun's rays. This defect does not belong to poppy seed oil.

Zinc white of good quality is ground in it to a paste form, and so labeled when offered for sale.

Poppy seed oil is a slow drier, so it requires a longer time for paint mixed with it to become dry. Its binding properties are no better than are those of linseed oil — if as good. Its high cost compared to that of linseed oil will always prevent its use. It is, therefore, but for expensive enameling that its use is ever resorted to by the general painter and decorator. Artists, of course, can afford to use it, *ad libitum*, in the very small quantities they require.

CHAPTER XIX

VEHICLES (*Continued*)

THE VOLATILE OILS

Spirits of Turpentine

IN defining the word *vehicle*, it was stated that it was a liquid medium with which pigments were mixed and properly thinned, so that they could be spread, by painting with a brush, over the surfaces to which the painter wished to apply them; that, through their agency, the pigments were made steadfast to these surfaces by those adhering or binding qualities of the vehicles, either possessed inherently within themselves, or added to them by the introduction and admixture of binding agents, as glue or gum arabic, etc., for water; the volatile oils serve another purpose in painting.

Their binding qualities are little better than water. This can readily be inferred from the fact that they evaporate entirely away, so that pigments mixed with them alone would have about the same chance of remaining upon outside surfaces as they would have if they were mixed with water instead — till the next hard rain came, which would wash them away; or some boy, even, without the rains, could rub the painting off with his bare hand.

The chief use of volatile oils in painting is for the purpose of rectifying some defects in the fixed oils that are used as binding vehicles in exterior painting, and for what is called *flattening* in interior work.

As adjuncts to linseed or poppy seed oils, they possess the property of intimately mixing with them, and of rendering them more fluid (they lessen their viscosity) and also make the fixed oil set quicker. This enables the painter to put on a heavier coat of pigment with less linseed oil than would be possible without the use of the volatile oils.

For flatting purposes they are used as the main vehicle. A sufficient quantity of linseed oil must be used to bind the pigment. It requires little to accomplish that purpose, so that finishing coats of flatting are nearly entirely of volatile oil. As flatting is usually done over a gloss coat — one containing considerable linseed oil — unless the flatting is delayed until the gloss coat has dried hard, there will be enough tack in that to hold the flatting thinned almost entirely with volatile oil. If, however, one waits till it has thoroughly hardened, a small quantity of linseed oil must be added to the flatting coat.

Spirits of Turpentine

Spirits of turpentine is the commercial term used in the United States to designate what the painter calls *turps* at the shop. In England, it is best known as *oil of turpentine*, which it really is. Both names refer to the same liquid.

It is obtained from several species of pines. That which has been so abundantly produced in America is derived entirely from the longleaf yellow pine of the tide-water section of the Southern States adjoining the Atlantic and the Gulf of Mexico. It is produced on a large scale by scarifying the trees and collecting the exuding gum which gathers at the wounds. This gum is a highly odoriferous semi-solid resin. This is gathered and hauled away to refining works, where it is distilled.

The volatile vapors are cooled and condensed into the *spirits of turpentine*, while the solid parts remain as *rosin* of many grades of goodness, according as it is very light or dark colored — the whitest being the most valuable.

Spirits of turpentine is the most valuable of the volatile oils used by the painter. Its odor, while it is strong and penetrating, is far from being disagreeable, and unless it is used during hot weather in a close room it is not unhealthy as are those oils derived from petroleum distillation.

Spirits of turpentine acts promptly upon the urinary organs, and it is strongly diuretic in action. Some men seem to be much more readily affected by it than others — some are so to the extent that they cannot endure to work with it long at a time; others again have worked with it daily for years without being detrimentally affected by it. Persons who are troubled with kidney diseases should be careful in its continued use. It is not only absorbed by direct contact through the pores of the skin, but also by the inhaling of its vapors, which soon permeate the atmosphere of a room where it is used, and where, as in flatting, little outside air is allowed to enter, and then it is inhaled at every breath in large quantities.

NAPHTHA AND BENZINE

Properties and Uses

For the purposes of painting, these two volatile oils may be treated together. Both are so nearly the same in composition, working qualities and odor, that they may be regarded as the one thinning vehicle in paint mixing. They are both derived from the distillation of petroleum, and in early days were in very bad repute.

They possess the properties ascribed to the volatile oils useful in paint mixing, and described under the heading of Spirits of Turpentine. They do not, any more than turpentine, possess any binding properties. As diluents of linseed oil, they are as good as and in some respects better than, spirits of turpentine, and in one instance they are not so good.

They are better, in that it takes less to accomplish the purpose for which they are used (the only legitimate use that can be made of volatile oils in paint), that of making a paint more liquid — spreading better.

But, phew! The smell! That is where the inferiority comes in. Their odor is repugnant to many persons, and to a few it is equal to a dose of lobelia or tartar emetic. They, too, act upon the kidneys and urinary organs, but not in such a marked manner as spirits of turpentine, and in addition they more than tax the stomach. For outside painting, they are better than turpentine, for the reason, already given, that it takes less to dilute the paint, so that more oil can be used and applied, and consequently the paint will not flat out so quick. It evaporates somewhat more quickly and sets the paint in a shorter time — another advantage.

The better grades of these oils are treated with a view to removing the disagreeable smell inherent in them, and while thus treated they do not smell nearly as bad as those which have not been *deodorized*; there is room for vast improvement in this respect. There is hope entertained of this. Spirits of turpentine is becoming scarcer and higher every day, and, at the rate that the Southern forests are disappearing under the ax of the lumberman, it is only a question of a few years when the quantity of it obtainable will be so small and its price will have soared so high that it cannot possibly be employed, as it was by

the general painter. In quantity it will have dwindled down to where there will scarcely be enough of it left to supply the demand of the pharmacists of the world, who all look to the United States for their main supply.

When that time arrives,— and it is plainly in sight now, willy-nilly,— naphtha and benzine must take its place. If completely deodorized, there will be no loss — at best, one might as well become accustomed to their use now; and artists, decorators, and others might as well quit shedding tears and accept the inevitable.

Aside from their uses as diluents, the volatile oils are powerful solvents of certain gums and resins of both hard and soft composition. Varnish manufacturers have been most liberal purchasers and users of them for that purpose, and increase each year, as the phenomenal increase in their output necessarily demands more and more.

CHAPTER XX

VEHICLES (*Continued*)

Varnishes, Japans, Alcoholic Solutions of Shellac, etc.

VARNISHES

General Remarks

UNDER the general name of varnishes, many differently constituted liquids are to be found. Naturally, according as to how these are composed and compounded, they vary in their characteristics, each being better adapted than are the others for some particular line of usefulness. The term *varnish* seems applicable to any liquid holding gums or gum-resins in solution, which upon the loss of its volatile parts, and upon the oxidation and hardening of its fixed oil and gum-resins, shows a gloss upon surfaces over which they are applied.

Some liquids will make a varnish (when properly treated) upon drying — as linseed oil will, after it has been heated at a high heat — but the gloss is greatly improved by the addition of gum-resins of various kinds.

In point of fact, no varnishes are made thus, and all may be said to be composed chiefly of gum-resins; the liquids used as solvents for these may be fixed oils, volatile oils or various mixtures of those two, or it may be alcohol as in the so-called *spirit varnishes*.

Properties and Uses

Varnishes — aside from the uses for which they are principally adapted, *i.e.*, the finishing of surfaces with a glossy coating, over paint put on in the ordinary way, in graining, or over car, coach or carriage work, or over the natural wood itself, as in hard-wood finishing, or in enameling or japanning — they are also used as a vehicle for the direct application of pigments. Enamel painting depends chiefly upon their use as pigment vehicles. Iron bed manufacturers, bicycle factories and japanning works, use them as vehicles, and they are true vehicles in every sense of the word, with this difference, that the fixed oils and their volatile adjuncts, are so of their own selves — while varnishes are not, but become so by the nature of their component elements, which, as was seen, are chiefly of those two classes of vehicles plus the gum-resins which also act as binders.

The painting must necessarily partake of the nature of its thinning varnish vehicle, some kinds of painting requiring certain varieties of varnish for thinners, and others, again, requiring different ones.

The varnishes which contain linseed oil as their principal solvent and which have hard gums in their composition — such as gum copal — are slow driers, but are elastic, and in some degree resist the elements. Such are designated for outdoor or exposed conditions.

Then for inside work, varnishes whose main solvent is turpentine or the petroleum volatile oils plus some linseed oil for binder, will be preferably used for inside work, as they dry hard, and being protected from atmospheric changes and moisture they answer fairly well for the purpose where hurry and expense are to be closely considered.

It is not intended in this work to give varnishes such attention and notice as would be expected in a treatise upon coach painting, for instance, as the only relation in which they are of any interest in connection with a book upon pigments is as to their use as vehicles of them. As vehicles, their glossy properties are secondary,—in fact, of no interest whatever even to the coach painter, with the exception of the enamelers, who do not varnish over their wares afterward.

To resume, then, in a few words their values as vehicles, the following advice is given: For permanent outdoor work, select some varnish made from hard gum resin dissolved in linseed oil; mainly of this description will be found the wearing body varnishes of the carriage trade, and some of the better carriage parts varnishes, and the so-called *spar* varnishes or outside varnishes, which are made to withstand hardships. Some few of the best grades of rubbing varnishes are also of this order.

For work that is not exposed, the better grades of the so-called *inside varnishes* are made from less expensive gum resins, and all of softer texture with a larger proportion of volatile oils, and will answer fairly well. There is a wide range between the poorest and the best, and one must be governed by the circumstances when selecting for certain purposes.

Some manufacturers list varnishes especially prepared for mixing with colors. However, if one has used a certain quality of varnish with good results, he should hesitate to continue its use, as he is likely to have some trouble at first with even a good new one with which he is unacquainted.

JAPANS

Properties and Uses

It is a very hard matter to give a true definition of what is really meant by the term *japan*, notwithstanding the daily use of it in the paint shop.

It is a *varnish*, and should be classed as such and with them. As popularly known and understood by many painters, it means to them simply a *liquid drier*. To the carriage trade and to the color grinders, it means a vehicle for the application of paint and for the grinding of it in; and to the japanners and to the enamelers, a *baking varnish*. In the last relation, it certainly is a varnish.

It is needless to say that japans vary as much in their composition as they do in their qualities, according to the formulas under which they have been made, and these are legion.

They can be divided into three classes. The first, which the house painters chiefly use are *liquid driers*, and consist principally of a solvent and some oxide of manganese. These are not varnishes in any sense of that word.

The second class, which are for grinding and applying coach colors, are properly varnishes, and of such are the gold sizes and coach japans, and in reality should be classed among the medium grades of varnishes. They make good vehicles for the purpose for which they are used. A great variety of good, bad, and indifferent coach japans are made, and the price paid for them is not always an indication of their quality.

THIRD CLASS

The varieties used in baking by enamelers are made so as to stand that operation. They evaporate under heat, and soften sufficiently to permit the coating of paint

to level up free from brush marks and then dry with a full gloss. There can be no doubt as to the character of these nor of the japans used by the radiator men. According to the gums entering in their composition, they are either good or bad. Manufacturers of bicycles and enameled iron bedsteads, etc., usually immerse all their commodities in a dipping tank and stand them on inclined drying boards, where the surplus color runs off, instead of hand-brushing the color.

These varnishes are probably called *japan* from the fact that all the small articles of bric-à-brac found on the market have a smooth finish, usually obtained by what is known as *japanning*, by baking in ovens specially constructed for the purpose. These articles are made to imitate in their finish the smooth *lacquering* put on the same class of ware imported from Japan and China. The name, no doubt, was transferred and applied from the country to the finish, and means that here. In so far it is easy enough to understand how such varnishes can be called *Japan*, but why the same name is used by the trade for mixing varnishes of the coach painter or the liquid drier of the house painter is one of the conundrums which life is too short to unravel.

ALCOHOLIC SOLUTIONS OF SHELLAC

Properties and Uses

Shellac varnish as it is sometimes called, or simply *shellac*, which to many means the same thing, and *spirits shellac*, as it is known in the British Isles, are all one and the same thing. It is simply shellac, either the orange or the white, dissolved in alcohol.

It makes a fair vehicle for pigments, where speed and quick drying are imperatively demanded. This varnish,

owing to the volatility of its solvent,—alcohol,—sets very quickly,—in a few minutes,—and in a few more it is dry and so hard that the painting done with it cannot be brushed over without marring it.

Owing to its setting so quickly, it is very hard to apply properly, and it requires an expert to handle it successfully. Its use must be confined to hurried work, and for that it has no equal.

The above concludes the list of vehicles used in painting,—at least those worthy of consideration.

There is a possibility of some others becoming very useful at some future time, but their cost is now too great to really entitle them to notice. Of this class is *China wood oil* or *Tung oil*, which is said to possess very good qualities. Should it be possible to acclimatize it here, and its cost brought somewhere near that of linseed oil, it might prove a dangerous rival; but it has never been given the proper tests for endurance, etc., which would warrant any one forming more than conjectural opinions concerning its possibilities.

Correctives are used with vehicles, as was intimated; and, again, some solids are *binders* to add to vehicles containing no binding properties. The next chapter will be devoted to these.

CHAPTER XXI

WAXES

BEESWAX

Properties and Uses

WAXES are not used as vehicles in painting,—as are the liquid vehicles,—owing to their property of solidifying in a few moments, at ordinary temperatures, as that makes it impossible to melt them, mix them with pigments, and apply the paint so mixed before it would have cooled and become so hard that nothing could be done with them in the ordinary way.

Encaustic painting, however, was known and practiced long before the present system of painting was so much as dreamed of. The ancient civilizations made use of it freely, and some of the work of their now unknown artists is occasionally found in as fresh and well-preserved a condition as when it was first applied centuries ago.

There is still some encaustic work done, but in an amateurish way, as artists much prefer the use of linseed oil to the slow and difficult method of applying paint by the encaustic process.

In encaustic painting the colors are first put on with a liquid,—water will answer as well as any,—and afterward the wax (when it has been melted by heat) is flowed over it. A flat, hot iron is used on it to obtain a perfectly level surface. The finish is certainly very pleasing; and the colors, being hermetically sealed from contact

with air, are not injuriously acted upon. It stands to reason that for the finishing of interiors at least such work must be permanent.

Beeswax was probably the form of wax used in the encaustic painting of the ancients, although they were also acquainted with the waxes derived from vegetable substances.

Beeswax is used for many purposes by the house painter,—in fact, all forms of waxes are,—not so much as a vehicle as it is for the finishing of floors or wood-work, and large quantities of it are annually consumed by the paint trade.

As it comes from the melting pots, it usually is of yellow, but often is found of a brownish tone; the latter being impure, it must be rectified and bleached before it is fit for the best work. The process of bleaching, also raises its melting-point and hardens it.

Beeswax is a vegetable product gathered by bees from plants, and is not an animal production as some erroneously suppose it to be. It is permanent for interior work, but when exposed to the inclemencies of the weather upon the outside, it is partially destroyed by oxidation.

VEGETABLE WAXES

Characteristics

Many plants produce wax, and in South America, especially in Brazil, it is gathered from the leaves of *Copernica cerifera*, where it occurs in thin sheets. It is a regular article of commerce in that country. In China and the Thibet there is an extensive trade done in vegetable wax. Its melting-point is high, 185° F. But for its limited quantity and consequent high price, it would

be more extensively used here; it makes a hard wax. Vegetable wax is used for all purposes indicated under the heading of beeswax.

PARAFFIN WAXES

Characteristics

Paraffin waxes are the product of petroleum distillation and vary very much. Most of them have such a low melting-point as to unfit them for encaustic painting or any other purpose of the painter. Their melting-point ranges from 105° to 180° F. The very highest qualities of them are very good, and in one respect at least render them superior to the vegetable waxes in that they are not so readily acted upon by the volatile oils, nor will they mix with them as those do. Such will consequently make excellent binders for pigments for encaustic work or for the waxing of floors where their hardness is greatly in their favor. It is also useful to add to such very heavy pigments as quicksilver vermillion, as it helps to prevent the separation and precipitation of that pigment when mixed in linseed or poppy-seed oils, but small quantities of it should be used for such a purpose.

While encaustic painting is commonly done by using the wax as a covering for the colors previously applied, and not as the vehicle to convey them to the work, yet there have been some very fine pictures painted where it was used as the vehicle for the mixing of the pigment and of its application. This requires great skill, and is not likely to ever become popular, as both the work itself must be kept warm as well as the vessels containing the melted wax and pigment.

CHAPTER XXII.
SUBSTANCES USED IN BINDING PIGMENTS
GLUES

General Remarks

THE substances whose description is attempted in this chapter are not vehicles themselves, being solid substances, but are adjuncts to liquid vehicles which do not possess any binding properties within themselves capable of fastening the pigments for the application of which they serve as a medium to surfaces and which otherwise through their lack of adhesiveness would fall down, wash away, or blow off from them upon on the least provocation.

In distemper painting, for instance, water is the vehicle used, and no arguments are necessary to show that paint applied with it would have absolutely nothing to hold it after the water had evaporated. These binding substances are added to hold the pigments to their place, and they become parts of the paint itself after the vehicle has evaporated.

Among the agents which are principally used for this purpose, *glue* easily holds first place, not that it is the best of all, but because it is the most economical as well as the handiest of any on the list. It is by long odds the one binding substance which is most universally used, and the quantity annually employed for the purpose is something enormous.

It is not only employed by painters in the preparation at the home shop of distemper colors, but the numerous concerns which have sprung up within the past twenty-five years with ready-prepared water paints or kalsomines or anti-kalsomines of all sorts, prepared from gypsum, etc., — which are all ready for use by the simple addition of either hot or cold water,— these use incredible quantities of it in the compounding of said ready-prepared distemper paints. This preparation of wall water-paints has grown up into a great industry and is extended every year, and they are found for sale in every general store in the land. They are uniform, handy to use, and usually give better satisfaction than that which the average painter is able to prepare for himself. The above is not said in order to discourage any one from mixing his own compounds, but as a statement of fact. There is no doubt but that any intelligent painter can mix a batch of distemper colors just as they ought to be; but although this is simply done, it must be done just right. In the hurry, which is usually the condition existing during the busy season of the spring, trifles are forgotten or discarded for want of time. Many a painter who has been too busy to properly prepare a batch of distemper color to be sent out on a job, sees it go out of the shop door with misgivings as to its future. Many an eyesore and heartache might have been avoided by the use of a well-prepared water paint which could have been sent out to a job without loss of time and saved a good bit of worry.

Properties and Uses

Glue is an animal product, obtained by the boiling of hoofs, bones, cartilaginous parts of carcasses, hides, hide trimmings from the tanneries, and even parts of flesh. If the treatment is done at a temperature above the

ordinary boiling heat, the process is greatly hastened. The various processes and manipulations are all simple and well known, but too lengthy to give, and can be summarized thus: Glue is the residue which remains by boiling the animal parts referred to and afterward drying the same when it has been cleansed of impurities by various processes of clarification, etc.

Its binding properties are due to two distinct yet similar compounds, *gelatin* and *chondrin*. The chemical composition of those bodies is carbon, hydrogen, nitrogen, and oxygen in various combinations. Both substances are entirely soluble in hot water and are coagulated by tannin. Cold will also coagulate them, hence the well-known property which is exhibited every time one mixes a pail of kalsomine,—it "jells" when it cools, which makes it work smoother and makes it easier applied than before coagulating.

Glues are thrown in three different classes, according to the material that was used in their preparation.

1st. *Hide glue*, made from skins, ears, tendons, hide trimmings from the tanyards, and similar offal.

2d. *Bone glue*, from hoofs, feet, bones, joints, and any osseous offal.

3d. *Fish glue*, made from the bladders, entrails, scales, and bones of fish.

All are well aware of the great difference in the strength possessed by various glues. This depends upon the material of which they have been made, and in a lesser degree upon the manner of their preparation.

Hide glues are the strongest of any, and possess the greatest tenacity. Bone glues are the weakest. It is difficult to make a glue salesman own up that any of his samples are bone glue, but some of them certainly are. Fish glue, especially that made from Russian stur-

geon stock, is very strong. Some of the fish glues made from the bladders are not only very strong, but as clear as glass, offering no obstacle whatever to the passage of light rays,—any more than would so much crystal. Isinglass is only a very fine form of such fish glue. The bone glues usually furnish that form of glue known as *gelatin*.

Glues range in color from that which is light and transparent to the dark brown stinking refuse, which forcibly reminds one of being very near a spot where animal matter is decaying.

That which is prepared for the binding of kalsomine or water colors is known to the trade as *kalsomine glue*. In shape it is in thin sheets, which are broken up in small pieces before packing in barrels. There are many qualities of it. That which breaks with an elastic fracture and is of a light creamy tone is usually good. If it is very white and opaque, the chances are that it has been weighted with some adulterating substance. These white weighted glues are not as economical nor as satisfactory as those of a creamy semi-transparent tone.

Glue comes also in a pulverized form, ground up in small, angularly shaped particles, and it is to be found thus in all grades from poor to good. Usually these do not run as strong as the regular kalsomine glues do, but the better qualities answer the purpose well enough. The ground glues dissolve more readily than those that have not been broken up, and the thin ones of the kalsomine glue sorts dissolve quicker than the thick glues. Glue, however, of any and all shapes, can be used for the purpose of binding pigments in distemper work. It is only a question of convenience, saving of time, and of a knowledge of the strength that they possess, as without that

it will be impossible to properly gauge the proper quantity of it to use for the binding of a given weight of pigment. Glue has the property of absorbing moisture and of retaining it when it comes in contact with cold water, but it is not dissolved by it. This well-known peculiarity is made use of by painters to hasten its solubility and to melt it. The glue is soaked in cold water over night. During that period, it will have absorbed several times its own weight of that liquid. It will then be swollen much above its normal bulk and softened in texture. This soaked and swollen glue, when placed in a vessel over the stove, will readily dissolve at a low heat, and thus will save much time and worry in melting it in the dry state, as then it requires constant stirring and much more heat besides care, or it will burn at the bottom of the vessel. When melted, it is ready to mix with the pigments, which should always be done before it has had time to cool and become jellied.

In warm weather, putrefaction commences early in colors thus prepared, and unless one has a refrigerator for the surplus that cannot be used the same day, it will be better and pleasanter to mix no more than will be used up clean that day.

To lessen the tendency to putrefaction, a few drops of carbolic acid or eugenol (oil of cloves) may be added. This will retard fermentation, but will not prevent it.

GUM ARABIC

Properties and Uses

Gum arabic is probably the best binding substance known for water colors, and if it is given only second place on the list, it is not because it does not deserve to have the first, but because its much greater cost and

also the greater care and difficulty in its use render its universal employment impossible; and also on account of another reason: if gum arabic was used to the same extent as glue is for binding pigments, there would not be enough of it in the market, and its cost would soar so high as to put it out of commission at once.

Gum arabic is a true gum, and consequently it is of vegetable origin. It is produced from several species of *acacia*. That best known is supposed to be produced from *Acacia Arabica*, and its name is derived from that; but in reality it is derived from *Acacia Senegal*, which is much more common, and the gum arabic of commerce is chiefly obtained from that variety.

Its composition is a mixture of the salts of arabic acid, these salts being of three bases, — potash, lime, and magnesia with water.

The better specimens are nearly all free from color, clear, and nearly if not wholly soluble in water, and the solution clear.

Gum arabic dissolves very slowly in cold water; boiling water must be used in making solutions. It should be pulverized to facilitate this, as it takes a long time to dissolve the lumps. After the solution is made, it should stand for a day, and the clear liquid poured off, when the undissolved impurities will be found at the bottom and should be left undisturbed. It should be prepared beforehand, so as to have it at a moment's notice. It will be well to guard against any fermentation by the addition of a few drops of eugenol or of a lump of camphor which will float upon the top; this will prevent it from souring.

Being so much more slowly acted upon by cold water than the glues, and being so much less subject to putre-

faction than animal matter, its use is indicated for distemper, fresco, and all good water-color work. For artists' use in water colors, it is indispensable.

The above two substances, *i.e.*, glues and gum arabic, are the two most important substances as binding agents for distemper colors. There are a few other substances used, but to so limited an extent as to deserve little more than passing mention.

These have been grouped below, and consist of *starch*, *dextrin*, *honey*, *molasses*, *sugar*, and *glycerine*.

STARCH

Properties and Uses

Starch is a substance well known to everybody, and is derived from the cereals and the bulbous roots of plants, as potatoes, yams, etc. Starch mixed with cold water into a stiff paste, and in which hot boiling water has been poured until it has become stiff and unctuous, has been and is occasionally used to mix pigments and apply them to surfaces. Its use for such a purpose can only be tolerated upon the plea of dire necessity, when no other and better binders are procurable, and cannot be recommended even for the cheapest kind of work.

DEXTRIN

Properties and Uses

The Dextrin of commerce is derived from starch. While its adhesiveness is greater than that substance, it is so much weaker than that of either glue or gum arabic, that its use is very questionable as a binder for distemper painting. It has another fault, in that it softens in warm

weather; and those who have had to do with sticky envelopes and stuck-together stamps will know enough not to want to fool with it.

As a corrective, used in small quantities with glues, it is said that it will prevent the suction of hot walls and keep the color from striking in too rapidly.

HONEY, SUGAR, AND MOLASSES

Properties and Uses

Honey, from its soft condition at all times, is not fitted for the binding of colors; *molasses* is similarly constituted; while *sugar* is a solid which by the addition of water can be brought to the consistency of syrup. The three possess about the same properties, and are too weak for the binding of water colors. As correctives to be used with distemper colors mixed with glue, they are frequently resorted to for the same purposes as mentioned under the heading of dextrin. Honey is also used as a corrective in the preparation of artists' water colors in the form in which they are so popular now, that of *moist pans*. It is also used in very limited quantity in the hard cakes to prevent the gum arabic in their compounding from becoming too brittle and crumbling to pieces. As honey usually becomes crystalline, and in that condition is as useless as granulated sugar would be, it is treated to prevent its crystallization, and has its dextrose removed. This is accomplished by mixing it with four times its bulk of alcohol and keeping it agitated every few hours for two consecutive days; then the pale alcoholic solution is filtered. It is fit to use in that condition, or the alcohol may be recovered by distillation, and the residue in a syrupy condition may be used instead.

GLYCERINE

Properties and Uses

Glycerine is obtained from oils and fats. Many of the large soap works produce it as a by-product. It is of the consistency of a thin syrup and has a sweetish taste. It attracts moisture readily, and will absorb more than one third of its weight from the atmosphere. That which is found in commerce has always some water in its composition. This can be readily detected by its specific gravity and the percentage of water computed from the variation of that which it shows and that which it ought to have. Its great attraction for water really makes it superior to honey in the manufacture of cake and moist cake water colors, and many are beginning to use it for that purpose.

It is also very useful to add to distemper colors and kalsomine for wall-work and for rooms where the plastering is in that condition which is known as *hot*. It will greatly facilitate the application of the paint into which it has been added in the proportion of four to six fluid ounces to the pail of color (about $2\frac{1}{2}$ gallons). Its use has saved many a man from profanity.

CHAPTER XXIII

DRIERS AND SICCATIVES

General Remarks

It has been noted in the descriptions of the various pigments that some of them were called *non-driers*. The pigments themselves, being powdered solids, never dry any more than they do when ground up with oil to a paste. The term, therefore, does not apply to them really, but to the linseed-oil vehicle with which they are mixed, and refers to the action of the pigment upon the oil. It was also noted that some other pigments on the contrary aided the drying of the fixed oils.

The main reason for the non-drying of pigments is that some contain fatty oils which do not dry; there are also other reasons which were noted under each head. Again, it was noticed that the lead pigments which were oxides of that metal, and that pigments also which contained oxide of manganese in their composition, hastened the drying of the oils.

The oxides of lead are all very good driers, but also some of the other salts of that metal and acetate of lead are especially so; even white lead itself possesses that property to a good degree but not in such proportion as some others. It will usually dry raw linseed oil in a few hours outside, without the addition of artificial driers unless the weather is cold and the atmosphere too humid.

In describing the drying of linseed oil, it was said that the heating of the linseed oil of itself rendered it more

siccative, so that even subsequently, after it had cooled, it would still retain some of its thus acquired drying quality.

Linseed oil would dry naturally when mixed with inert pigments, as these exert no influence upon its drying one way or another; and with the pigments, which will aid its oxidation the more quickly, as these part with their oxide more rapidly or liberally, and when mixed with the non-drying pigments much more slowly or not at all, according to the composition of the non-drying colors. If the temperature could be depended upon to remain above 70° F., and the barometer at "Beau Fixe," and only pigments mixed with linseed oil which were not inimical to its natural drying, there would be but little need of *driers*; but, unfortunately, there can be no dependence placed upon it. Neither the thermometer nor the barometer ever remain very long where the painter would like them to be, being proverbially fickle, so, by the use of dryers, he must guard against the possibility of having his work destroyed by changes which are likely to come at a moment's notice.

Again, in interior work, the women folk are ever hurrying up the poor painter, and ever threatening all sorts of evil to him, even to threatening him that this is to be the last job for him there, if he does not put in a little more push to his hastening along with it, when he is doing all that possibly can be done, and more, for the real good of the painting; or in business houses or stores, where the painting has to be done at night, so the paint may be dry in the morning, there is no other alternative left to the painter but that of using siccatives in his paints, no matter whether this is good for it or not.

There is no doubt but that much of the short life of paint complained of is due, in part at least, to the hurried

drying of linseed oil, which *burns it up* — that is what fast drying means. Where the drying is slow and natural, the conversion occurs without violence. Then the paint will stay on much longer and remain in good condition without checking all over from lack of adhesion and elasticity.

BOILED LINSEED OIL

This is the simplest of the siccatives.. The heating of linseed oil renders it more drying. Boiled oil, when the boiling has been done, as it usually is, with the oxides of lead or manganese present during the process, renders it still more drying.

How those substances are capable of imparting oxygen to linseed oil without losing any of it themselves is not well understood. One thing is sure, if a given weight of those oxides be placed in a bag with the oil and all boiled together, these bags may be taken out and the linseed oil carefully washed away with benzine, and the oxide powders dried and weighed, when it will be found that they have not lost any of it by the operation, but the linseed oil will have absorbed oxygen through their agency some way.

As a siccative, boiled oil has its uses even for outside painting, but it is seldom used for that purpose, probably because the specially prepared liquid driers or japans are more powerful siccatives and smaller proportions are necessary to accomplish the purpose of drying the oil.

LIQUID DRIERS

General Remarks

Manufacturers of varnishes usually prepare siccative compounds for the drying of linseed oil. They are sold

under many names, such as *drying japans*, *liquid driers*, *liquid siccatives*, and many fancy proprietary names.

The solving medium used in their preparation is really of little moment, whether it be linseed oil, spirits of turpentine, naphtha, benzine, or mixtures of these. The quantity necessary to dry a given amount of linseed oil is so small that their presence in the oil can exert little influence other than that which is expected of them — the drying of the oil. An undue quantity added to linseed oil will injure it, but then that would happen no matter what the solvent might be.

LEAD OXIDES

The action of these has already been noted, as, for instance, when boiled with linseed oil, etc. All lead siccatives have one drawback that they all hold in common, they subject the oil, or rather the pigments mixed with it, to the action of sulphuretted hydrogen.

This is not so noticeable in the liquid driers as it is in the paste driers, when the lead oxides themselves become a part of the paint.

The paste driers will be noted further on more fully.

Liquid driers are very seldom, if ever, made from the lead oxides, for the very good reason that the

OXIDES OF MANGANESE

are much better adapted for that purpose. When made with these, there is no danger of any further discoloration taking place, outside of that which is produced immediately after the mixing of the liquid manganese drier with the paint. The greatest drawback is their dark brown color. If, however, the brown borate of manganese is used in the preparing of the liquid drier, the dark tone of the drier will be reduced to a minimum.

The manganese driers are such strong driers that, if they have been well prepared, but little of them need be used, and that little will influence the drying of linseed oil a long way.

There is absolutely no excuse for using the large quantities of liquid manganese driers many painters do. It then becomes dangerous, for it burns the paint, and, in excessive quantities, it will defeat the purpose for which it is used at all — the drying of the oil. When will the careless painter learn that a little manganese drier will accomplish the object of drying oil much better than the larger quantities of it. Strange as the above may sound, it is not the quantity used that causes the oil to dry faster, for it will take it up only as it needs it — at its convenience, nor will it take up more than the needed amount. Another strange fact, hard to explain, is that when excessive quantities are used the very object of quick drying is defeated, as then it seems rather to prevent than accelerate it. One large tablespoonful of a well-made standard average strength liquid drier is amply sufficient for any ordinary pail holding three quarts of paint ready thinned for application. This will dry all ordinary mixtures where white lead is the base of the paint. For vandyke brown and lamp black, half a pint to the gallon of linseed oil will be found sufficient — those two pigments being the most anti-drying ones on the list.

PASTE DRIERS

The oxides of lead, we have already seen, affect white lead compound and others even more, which are not affected by sulphuretted-hydrogen gases, which, when they are used, are affected by their presence.

Formerly large quantities of acetate of lead paste driers were manufactured, but their defects under

unfavorable conditions — specking and coming out as an efflorescence — have greatly reduced their use. Under that form and style they are still used in certain localities.

Paste fillers are made and prepared according to proprietary formulas, so that what might be a good one made by one firm will not necessarily need to be a recommendation for some one else's make, simply because it is put up in that form. Acetate of lead is the base of all light-toned ones. They are used for very light tints and whites. Many an artist has had to rue the day when he was tempted to use them, as they are chiefly composed, as was said, of acetate of lead, or may also contain white oxide of lead or litharge, which, however, darkens it some. Aside from subjecting the painting to the action of sulphurous vapors, deteriorating and specking or efflorescing, there are other injurious chemical changes affecting them.

Sulphate of zinc drier in paste form is a fair drier for zinc white, but of little value when used in connection with any other pigment.

Borate of lime and borate of zinc also make useful driers for zinc paint.

Some paste driers are now made with borate of manganese as the chief ingredient in their composition. Such will be found more effective and more valuable, even if they are a trifle dark, than the other varieties of paste driers, but they are not as advantageous as the liquid driers. They require to be carefully thinned out before mixing with the paint, and for that reason will never become popular. It is a waste of time to triturate them and thin them for use, which, when done, puts them in liquid form and makes a liquid drier of them after all. Why not procure that in the first place and save all the bother?

CHAPTER XXIV

THE COMPOUNDING OF PIGMENTS.

THE compounding of pigments changes the color of each, imparting to the others a part, and in return receiving a part of theirs, so that the completed mixture becomes a new color different from that of the pigments producing it, but which partakes of the character of each one of them in some degree.

THE PRIMARY COLORS

Of colors proper there are but three. These three are called the *primary colors*. They are the following:

Red, Yellow and Blue

White itself is but the product of a *perfect* combination of the three primaries, *black* being simply a negative of all color.

SECONDARY COLORS

From the combination of two of any of the primary colors together are made the *secondary colors*, and these are as follows:

Purple, Orange and Green

They are thus produced:

Red and blue = Purple.

Red and yellow = Orange.

Yellow and blue = Green.

TERTIARY COLORS

From the union of two of the secondary colors comes a third set, the *tertiary colors* which consist of the following:

Olive, Citrine and Russet

They are derived in this way:

Purple and green = Olive.

Green and orange = Citrine.

Purple and orange = Russet.

Further mixtures of these produce the *neutral tints*.

From the above three primaries, three secondaries and three terciaries, with the addition of white and black, are produced the hundreds of thousands of varied tints which form the kaleidoscope of infinite variety adorning everything animate and inanimate upon this mundane sphere.

It is regrettable that no more space can be devoted to the study and notice of color harmony, but this would unduly enlarge the volume, and it is not strictly within the subject matter. The color student is therefore advised to procure some of the excellent treatises which deal with this subject as their primary object. There is nothing more interesting than the study of the phenomena of color. It will greatly help the student, not alone in that it will help him to mix tints properly, but also in the higher object of becoming *master of color effects*, which is a faculty that few otherwise very good painters possess, and which would be worth to them in after life many times over whatever effort in time and money they may have spent in acquiring a good knowledge of color.

Expert colorists are in good demand at any reasonable figures which they may demand for their services.

For the making of tints, a *base* is used upon which to build it. The base is that pigment which enters the compound in the greatest quantity. If a white, — and that is usually the base of all light tints, — it is either white lead or zinc white, used alone or together in any proportions, and still other whites may be added to them as correctives if desired.

The rules given below are formulated for guidance in the preparation of tints, with linseed oil as the vehicle, and for pigments which have been ground to a paste in the same vehicle. These same rules will apply to the mixing of pigments and the making of tints from them in any other vehicle, japan, varnish or water, with whatever slight alterations made necessary by the different nature of those liquids.

1. THE BASE

The base, as was said before, is the *principal color* of the tint. Tints usually, but not always, are lighter tones of those of the pigments used in compounding them, so white must be used to lighten them up. It thus becomes the principal color or the *base* upon which the tint is built. It may be any white pigment, or combination of them; but to simplify matters, and also on account of its being the pigment in chief use for the purpose, when a white base is designated hereafter it will be called *white lead*, no matter if it is that or any other white that one may prefer to use.

In some few cases, however, where great purity of tone is necessary, and for certain kinds of interior work, zinc white should be substituted. With these explanations one cannot greatly err. It will be an easy matter to substitute zinc for lead, when it is well understood that the white lead base that is indicated in the next

chapter does not stand as meaning that especially, but only a white base as the predominating pigment.

The white lead or zinc white or other accessory whites must have been *broken up*, as is called the operation of taking it out of its original package or keg in which it was placed at the factory — and thinning it with sufficient linseed oil to make a rather stiff and smooth paste. It is not such an easy matter as it may look, to a novice, to stir up the lead and to get it into a smooth uniform mass free from lumps. It is simple, but it means hard work, requiring strength and effort to perform it properly. Some use a little turpentine with the oil, to make it break up readily, and the small quantity required will not harm it for any purpose of outside painting. If possible, the breaking up should be done the day before preparing the tints; if left over night many of the small lumps, which seem to defy the paddle and constantly escape it, and which are a cause of mental irritation, and thereby of profanity, become soaked up by the linseed oil when left in contact with it over night, and the next day the mass is more easily brought to a uniform smooth paste. The tub or tubs used for the breaking up of the lead should always be ready to furnish the base in just the shape described, as it will be found much better than freshly broken up lead for the purpose of preparing tints. Of course, it is not *absolutely necessary* that it should be broken up ahead of the time it is needed, but it will be found better, and the better way is what the author is trying to inculcate.

2. THE COLORING PIGMENTS

These, too, should have been previously broken up by the gradual addition of small quantities of linseed oil. When the pigment has been beaten up with the oil, and

has absorbed all the oil, forming a smooth paste of uniform texture, more is added and triturated with it, till again that is absorbed, and a liquid is obtained which pours out easily — as thin as one would wish to apply with a brush. It is only when in this condition that the coloring pigments can be added to the base safely, as otherwise they will not incorporate with it with anything like uniformity, and the tint may be streaky, which is an abomination and a sure sign of the incompetency of the tint mixer.

3. MIXING THE TINTS

The pigments must be added slowly to the base, so as not to overshoot the intended tint. It is an easy matter to add more pigment to the base, if it is needed, to bring it to the intended tint, but it is impossible to take it out if the addition has been overdone. This overdosing is called, in painter's parlance, *drowning the miller*.

Tints made by the simple addition of one coloring pigment to the base are readily handled by following the above directions.

MIXING COMPOUND TINTS

If more than one coloring pigment is required to produce a given tint, the first in importance in the mixture should be added to the base up to a point just short of that which it is thought its due proportion should enter into the compound. The next one in importance should then be added to the base, and that, too, stopped short of that which it is thought it should be, and the same process continued for each pigment entering the compounding of the tint. After the mass has been well stirred, and has become uniform throughout, it will then be an easy matter to add a bit more of this or that color, if there is need of it, to bring it to the exact shade of the tint that is to be matched.

If one has been careful to stop short of the quantity thought to be required, as is easily seen, it will be readily remedied; but if, on the contrary, one has not stopped in time, and has overdone it, putting too much of the pigment in it, then the mending will be more difficult. It will require, in the first place, an increase in the quantity of the base, proportionate to the excess of coloring pigment used over and above the right amount, so that one will be forced to mix up a larger quantity of the tint than was intended or may be required, which means a loss.

If one has poured in too much through accident, and is aware of it, it is sometimes possible to dip out the color so poured in, or the most of it, before it has been mixed with the base; it will then not be necessary to add much, if any, of the base color. The waste is then reduced to a minimum. Then proceed to thoroughly mix, after which add the other coloring pigments, as directed, and lastly a portion of that which was dipped out — just so much as is needed to bring the tint to the desired shade. The remnant will be so small a loss, that, in comparison with the other waste mentioned, it will be hardly worth speaking about.

PREPARING TINTS READY FOR USE

When a tint has been compounded to the perfect satisfaction of the mixer, as when the lead has been well broken up and used, as it should have been, in the form of a very stiff paste, and if the tinting pigments have been thinned well, so they could be easily incorporated with the base, and the whole has been well stirred up so that the paste is of a uniform consistency throughout, it will be found rather stiff — much too stiff for application with a brush. But the condition it is in then is just the

right one for transportation, as it can be dipped out into stock pails and transferred to the job where it is to be used, without any danger of its slopping out, as it would surely do had it been thinned out to the point needed for its application.

It is, of course, impossible to give very definite directions about the thinning, as circumstances vary so much that the experience of the man behind the brush must be used here. No directions, other than the most commonplace ones, can be given, *i.e.*, thin out more for first and second coats than for third, and more all around for spongy surfaces than for such as have little or no penetration.

The above directions will suffice to enable anyone to mix tints properly — in oil.

For coach painting, the same care must be exercised as directed for tints made in linseed oil in adding the coloring pigments to the base, the main difference being in the thinner, which is either japan or varnish and volatile oils. There is little, if any, compounding of tints in coach painting, the colors used for that work being self ones, or, if compounded at all, that is usually done at the factory.

For distemper painting, the pigments coloring the base — which is usually whiting — should be mixed separately as for oil colors, only that they should be made more fluid; otherwise all that was said before applies to them also. The thinning fluid being water, instead of linseed oil, japan, or varnish. After the tint has been finished to the satisfaction of the mixer, the melted glue or the dissolved gum arabic can be added. It is much more difficult to tint shades up to a given sample in distemper than it is in the preceding vehicles, for the reason that pigments mixed in water do not

appear the same as when dry, which in oily mediums they do. In water they appear very much darker than they are after drying. There are no exceptions to that universal peculiarity, so that a tint mixed to the exact shade of a dry sample, when first applied, would be entirely too light when dry. The tints should be made very much darker than the sample to be matched, and a small patch should be painted over a piece of paper, and the same placed in a warm sunny spot or over a stove so the water will evaporate quickly, and, when dry, the tint can then be compared to the sample, and if not deep enough more of the tinting pigment must be added until the tint has attained the same tone as that of the sample. This may require several times testing it, by drying it upon the piece of paper, but it is the only safe way, and any other method would be but guess work.

It requires considerably more experience on the part of the mixer to *hit* a tint just right in a quick way. Few men can fall into it at once. In time, the experience gained by many former failures will gradually work up into *intuition*, for that is what it seems to the man who has tried it a few times but could not do it.

CHAPTER XXV

A LIST OF SOME OF THE PRINCIPAL TINTS AND HOW TO MAKE THEM

General Remarks

IT is deplorable that the English language has no well-defined nomenclature to designate tints. As other languages have not got any either, it is not behind them any in this regard; but it is deplorable nevertheless.

If one is inclined to doubt this, let him procure the color cards of a dozen manufacturers of mixed paints, where the tints are known and sold by name, as well as by number, and these names printed under the tints. It will be found upon inspection that it will be rare if any two out of the dozen look alike. This is especially true of the neutral tints, or those tints which are neither primary, secondary, nor tertiary. Owing to this lack of uniformity, some persons may think that they have not been successful in obtaining the *right tint* if they get something which does not come up to their conception of what the tint ought to be, and may think that the directions given as to how to make them are wrong, or that the colors used in the making were off; all but the right conclusion perhaps — that what they call a gray may be somebody else's drab. If he follows the directions for making a gray, and his own ideas of a drab being that the gray fits them, it will certainly be a hard matter to convince him that he is wrong, because there is no accepted standard recognized to settle it

beyond dispute. Again, if the directions be given for the making of a sage green, and the tint happens to be what he conceives is a myrtle green, or an apple green or a light olive, who will say that he is wrong? Surely, when well-trained men differ so widely among themselves, how can others, who have only given the study of color the most superficial examination, be expected to do better? Nature itself varies exceedingly, and tints which are named after the prevailing tones of green of certain trees or plants are bound to form a subject of endless and profitless controversies as to what is the proper tint. Take instances, outside of the vegetable kingdom, out of that of animals: Peacock blue — where is the standard for that? Let anyone undertake to furnish one, and out of a dozen men, at least ten would demur to it! If the whole dozen undertook to furnish the standard, there would be precisely twelve supplied.

So, when directions are given for the making of such far-fetched named tints that fashion has given birth to; such as baby elephant's breath, cataract's mist, etc., would many be found sufficiently æsthetic to forthwith fall into the idea of it, or, if they did, would they coincide as to the proper tints to represent them?

These precautionary words are necessary to warn the reader that he must not expect too much (or the impossible) from the general directions given for the compounding of tints by name. The quantity, by weight, of pigment to be used in producing them has been left blank for the very purpose of enabling the mixer to suit himself if possible as to the depth, and in more than two pigment compounds to some extent as to the tone. This will give the mixer a chance to use some judgment of his own, and if he has noted the direction given, not to *drown the miller*. He will have the tint light enough so

that he can add more of the coloring pigments named to produce the tint of such depth and tone as he requires it to be.

There is still another very important reason why weights are not given. It must have been made very plain to the readers of this treatise, who have followed the descriptions given with each pigment, that there is a vast difference in the strength of coloring matter contained in a given weight of various samples of most of them. If one man took a recipe made up in pounds and ounces he would obtain a tint that would bear no resemblance to that obtained by the very same recipe in some other locality, where the coloring pigments were made up by another manufacturer. Thus, if a recipe should say:

Take White lead	20	pounds
Venetian red	3	"
Medium chrome yellow . .	1	"

If operator No. 1, should use a pure chrome yellow and a good-toned venetian red; operator No. 2, of the same town, using a chrome yellow, containing but 20 per cent of color, and an indifferent venetian red, would have an entirely different tint, and it would be due to the recipe giving precise weights. Had the same been left blank, the chances are that the difference would not have been so great — at any rate, the mixer would have had something nearer to his liking.

LIST OF PRINCIPAL TINTS

For the purpose of easy reference in the finding of any particular tint, they have been listed alphabetically.

The base pigment, or the principal one of the compound, is invariably named first. The other coloring pigments are named in the order of their importance

in the make up of the tints. Therefore, of the last, frequently but a very small portion need be added. As far as possible, where a simple tinge or reflection of a color is needed this will be indicated:

Acacia. Lamp black for base; color it up with Indian red and tinge with Prussian blue.

Acorn Brown. Similar to chocolate which see — but lightened with white lead.

Alderney Brown. Lamp black; orange chrome yellow; Fr. ocher; white lead.

Amber Brown. Burnt sienna for base; add orange chrome yellow, burnt umber, a trifle of lamp black, lighten shade to suit by adding white lead.

Amaranth. Tuscan red and vermillion in about equal parts for base; add enough ultramarine blue to suit shade of it wanted.

Anemone. Vermilion red for base; Prussian blue and a little black and white lead.

Alabaster. White lead for base. Give it a very faint tinge of medium chrome yellow.

Apple Green. White lead for base; add light chrome green and orange chrome yellow.

Antique Bronze. Orange chrome yellow for base; add ivory black; lamp black can be substituted, but the shade will not be so rich.

Apricot. Medium chrome yellow for base; venetian red, carmine lake, if light shade is wanted lighten it up with white lead.

Armenian Red. Bright Venetian red for base; lighten up with French ocher.

Ash Gray. White lead for base; tinge with lamp black, add a bit of French ocher.

Asiatic Bronze. Raw umber for base; medium chrome yellow to which add sufficient white lead to suit shade wanted.

Ashes of Roses. Light Tuscan red for base, to which add a trifle of lamp black.

Autumn Leaf. White lead for base, to which add French ocher, orange chrome yellow, a trifle of Venetian red, sufficient to slightly reddens tone with more of it, if a deeper-toned red is desired.

Azur Blue. White lead for base; add Prussian blue to shade desired of it.

Bay. Lamp black for base; add Venetian red and orange chrome yellow.

Begonia. Lamp black; vermillion red of a good scarlet shade, tinge with Prussian blue.

Bismarck Brown. Burnt sienna for base; add burnt umber, orange chrome yellow. Lighten slightly with white lead to suit.

Black Slate. Lamp black for base; Prussian blue, slightly lightened up with white lead.

Bordeaux Blue. Lamp black for base; orange chrome yellow, Prussian blue.

Bottle Green. Prussian blue and lamp black for base, and lemon chrome yellow. To obtain this tint at its best, it should be glazed over afterwards with a yellow lake.

Brass. White lead for base; add medium chrome yellow; French ocher to tint wanted.

Bronze Red. Vermilion red for base; orange chrome yellow; lamp black.

Brown Stone. Tuscan red for base; add orange chrome yellow; lamp black; lighten up to suit with white lead.

Brick Color. Yellow ocher for base; add Venetian red to suit, for very light shades add white lead in very small quantity.

Bronze Green. Extra dark chrome green for base; add lamp black. This makes a fair bronze green. If extra dark chrome green is not obtainable, use the dark or even medium chrome green with more of the lamp black to darken the tint.

Another recipe is given for a richer tone of it; medium chrome green for base; add ivory black and a trifle of raw umber to shade wanted.

Bronze Yellow. Medium chrome yellow for base; raw umber; lighten up with white lead.

Browns, all shades and Brown Drabs. Venetian red for base; add French ocher and lamp black in various proportions according to the shade of brown wanted. For the brown drabs add white lead to the above brown tints, to the desired shade.

Buttercup. White lead for base; add lemon chrome yellow to suit.

Cambridge Red. Vermilion for base; add Prussian blue to suit.

Café au lait. Burnt umber for base; add white lead; French ocher; Venetian red.

Carnation. English vermillion for base; add some good madder lake or carmine. If desired very light, add some zinc white.

Cerulean Blue. Zinc white for base; add ultramarine blue, but better use cobalt if procurable and genuine.

Cherry Red. Vermilion for base; add burnt sienna; crimson lake; ultramarine blue.

Chamois. White lead for base; add French ocher; medium chrome yellow to suit.

Chartreuse. White lead for base; add medium chrome yellow; medium chrome green.

Chestnut. Venetian red for base; add medium chrome yellow; French ocher and lamp black.

Chocolate. Burnt amber for base; add some rich crimson vermillion or madder lake.

Another way is French ocher for base; add lamp black and a little venetian red to suit.

Canary. Use the chrome yellow sold under that name.

Another way is to take lemon chrome yellow to which add zinc white to reduce to tint wanted.

Claybank. French ocher for base; add orange chrome yellow; lighten up to shade wanted with white lead.

Claret. Madder lake and ultramarine blue for base, to which add some English vermillion and ivory black.

Clay Drab. White lead for base; medium chrome yellow; raw and burnt sienna.

Cinnamon. White lead for base; add burnt sienna; French ocher; medium chrome yellow.

Cobalt Blue. This is a solid blue. Use blue sold under that name. If not obtainable, take good ultramarine blue for base, to which add sufficient zinc white to lighten it to shade required.

Coral Pink. Vermilion for base; white lead; medium chrome yellow.

Colonial Yellow. White lead for base; add medium chrome yellow; orange chrome yellow to tinge it

Cocoanut Brown. Burnt umber for base; lighten up with white lead.

Cotrine. White lead for base; add orange chrome yellow and lamp black.

Cream Color, and all the buffs. White lead for base; add some good French or Oxford ocher to tint wanted; this will make all the cream and buff tints from very light to very dark by adding more or less of the ocher.

Copper. Medium chrome yellow for base; add venetian red and a little of lamp black.

Citron. Venetian red for base; add medium chrome yellow with some Prussian blue just to tinge. If too dark, lighten up with white lead.

Crimson. Dark English vermillion or any of the dark shades of vermillion reds. If desired very rich toned, add some good madder lake or carmine.

Dove Color. White lead for base; add ultramarine blue; Indian red and lamp black.

Dregs of Wine. Dark Tuscan red for base; lamp black and a trifle of zinc white.

Electric Blue. Ultramarine blue for base; add white lead and raw sienna.

Ecru. White lead for base; add French ocher; burnt sienna; lamp black. This tint varies greatly. Its meaning is *raw* and is intended to represent the color of raw flax, before it is bleached.

Emerald. Paris green as it is or an imitation of it made from a very pale chrome green of a bluish cast or slightly tinged with Prussian blue.

Egyptian Green. White lead for base; add raw umber; lemon chrome yellow; Prussian blue to suit.

Fawn. White lead for base; add medium chrome yellow; Venetian red; burnt umber.

Flesh Color. White lead for base; add medium chrome yellow; French ocher; and Venetian red.

French Gray. White lead for base; add ivory black with a faint tinge of ultramarine blue and madder lake or carmine.

French Red. Indian red for base; add English vermillion to brighten it, then glaze with madder lake or carmine.

Gazelle. French ocher for base; add dark Tuscan red; venetian red; lamp black; lighten up with white lead.

Geranium. Vermilion red for base; add Indian red and lamp black.

Gobelins Blue. Ivory black for base; add white lead; Prussian blue; medium chrome green.

Gold. White lead for base; add medium chrome yellow; some good French ocher; and a very little vermillion red or English.

Goldén Brown. French ocher for base; add orange chrome yellow; lamp black; lighten up with white lead to suit.

Gray Green. White lead for base; add ultramarine blue; lemon chrome yellow; lamp black.

Grass Green. Extra light chrome green just as it comes from the can. For an extra fine job glaze with Paris green.

Green Stone. White lead for base; add medium chrome green; raw umber, and French ocher.

Gray Stone. White lead for base; add lamp black; Prussian blue; Venetian red.

Gray Drabs. All shades of them. White lead for base; add lamp black or ivory black with a little burnt umber in various proportion according as a light or deep shade of drab is desired.

Greys. Light to dark shades. White lead for base; lamp black in various proportions to suit shade wanted.

Hay Color. White lead for base; add orange chrome yellow; light chrome green; Indian red.

Heliotrope. Zinc white for base; add bright Venetian red; ultramarine blue.

Indian Pink. White lead for base; add Indian red.

Indian Brown. Indian red for base; add lamp black; French ocher.

Iron Gray. Lamp black for base; add white lead and a trifle of orange chrome yellow.

Ivy Green. French ocher for base; add lamp black; Prussian blue.

Jasper. Lamp black for base; add white lead; medium chrome yellow; light Indian red.

Jonquil. White lead for base; add medium chrome yellow to which should be added a tinge of red with English pale vermillion to enrich it.

Lavender. White lead for base; add ivory black; ultramarine blue; tinge with carmine or madder lake.

Lead Color. White lead for base; add lamp black and a trifle of Prussian blue. The latter can be omitted, if the lamp black is good.

Leather. French ocher for a base; add burnt umber. If a warm tone of it is desired, add some Venetian red.

Lemon. Use lemon chrome yellow just as it is.

Leaf Buds. White lead for base; add orange chrome yellow; light chrome green.

Lilac. White lead for base; add dark Indian red to suit.

London Smoke. Yellow ocher for base; add ultramarine blue; lamp black; lighten up to suit with white lead.

Magenta. Vermilion for a base; add carmine or madder lake with a tinge of ultramarine blue.

Mauve. Yellow ocher for base; add Venetian red; lamp black; lighten up to suit with white lead.

Mastic. White lead base; add French ocher; Venetian red, a trifle of lamp black.

Maroon. Carmine or madder lake for base; add ivory black and a small part of orange chrome yellow — another way; Tuscan red for base; add orange chrome yellow with a trifle of ivory black.

Manila or Deck Paint. White lead for base; French ocher; medium chrome yellow.

Marigold. Medium chrome yellow for base; add white lead; orange chrome yellow.

Mexican Red. Bright Venetian red for base; red lead.

Mignonette. Medium chrome green for base; add Prussian blue; medium chrome yellow; lamp black.

Moorish Red. Vermilion red for base; add rose pink or, what is much better, madder lake.

Mouse Color. White lead for base; add lamp black, a tinge of Venetian red and burnt umber.

Moss Rose. Lemon chrome yellow for base; add medium chrome green; lighten with white lead to suit.

Mulberry. Ivory black for base; add vermillion red; trifle Prussian blue.

Myrtle Green. Dark chrome green for base; add ultramarine blue; lighten up with white lead to suit.

Nile Blue. White lead for base; add Prussian blue; with a trifle of medium chrome green.

Normandy Blue. Medium chrome green; ultramarine blue; a trifle of white lead.

Nut Brown. Lamp black for base; add Venetian red; medium chrome yellow; French ocher.

Oak Color. Light and dark shades of it. White lead for base; add French ocher; also a small quantity of Venetian red. Vary the quantities to suit for light or dark shades.

Old Gold. White lead for base; add medium chrome yellow; French ocher and a small portion of burnt umber.

Olive. Lemon chrome yellow for base; add about equal parts of Prussian blue and lamp black. Some shades of olive can be made by substituting French ocher for the lemon yellow; in such a case the tone will not be so bright. A trifle of the lemon chrome yellow added to the ocher will improve it and make still another variety of olive tones.

Orange. Orange chrome yellow, just as it comes from the can. If not to be had, take medium chrome yellow and color it up with a bright scarlet red — any scarlet-toned vermillion will do.

Olive Brown. Raw umber for base; add lemon chrome yellow. Vary the quantity to suit the intensity of shade wanted.

Orange Brown. Orange chrome yellow for base; add raw sienna; a trifle of burnt umber.

Oriental Green. Raw umber for base; add lemon chrome yellow to suit.

Opal Gray. White lead for base; add burnt sienna; ultramarine blue.

Peach Blossom. White lead for base; add pale Indian red to suit. A tinge of madder lake will enrich it, but is not a necessity.

Pearl. White lead for base; add ivory black and a trifle of ultramarine blue and carmine red. It is a very light shade, just off the white; do not overdo it.

Pea Green. White lead for base; add medium chrome green to suit.

Peacock Blue. Ultramarine blue for base; add extra light chrome green and zinc white to suit.

Persian Orange. Orange chrome yellow for base; add French ocher; white lead.

Pink. Zinc white for base; add madder lake or carmine or the crimson shades of English vermillion.

Pompeian Red. Vermilion red base; add orange chrome yellow; ivory black.

Pompeian Blue. White lead base; add ultramarine blue; vermillion red; French ocher.

Plum Color. White lead for base; add Indian red; ultramarine blue.

Portland Stone. French ocher for base; add raw umber; lighten up with white lead.

Pistache. Ivory black for base; add French ocher; medium chrome green.

Purple. White lead for base; add dark Indian red; a trifle of light Indian red to suit.

Primrose. White lead for base; add lemon or medium chrome yellow, according to the shade wanted of it.

Purple Brown. Dark Indian red for base; add ultramarine blue; a trifle of lamp black and white lead to lighten it up.

Quaker Green. White lead for base; add French ocher; lamp black and burnt sienna.

Roan. Lamp black for base; add Venetian red; Prussian blue; lighten it up to suit with white lead.

Robin's Egg Blue. White lead for base; add ultramarine blue until the shade is a pretty deep blue, then add some pale or medium chrome green to suit tone desired of it.

Russet. White lead for base; add orange chrome yellow; a trifle of lamp black.

Russian Gray. White lead for base; add ultramarine blue; pale Indian red and lamp black.

Sage Green. White lead for base; add medium chrome green until the tint is nearly but not quite a pea green, then add lamp black to bring it to the sage color.

Salmon. White lead for base; add French ocher; burnt sienna; with a trifle of English vermilion or a good vermilion red.

Sapphire Blue. Zinc white for base; add ultramarine blue.

Sap Green. White lead base; add medium chrome yellow; lamp black.

Sea Green. White lead base; add Prussian blue; raw sienna.

Seal Brown. Burnt umber for base; add good French ocher and a trifle of white lead.

Scarlet. Pale English vermilion or any of the scarlet-toned vermilion reds.

Shrimp Pink. White lead for base; add Venetian red; burnt sienna and a trifle of vermilion.

Sky Blue. White lead for base; add Prussian blue to shade wanted.

Slate. White lead for base; add raw umber; ultramarine blue; lamp black.

Spruce Yellow. French ocher for base; add Venetian red; lighten up with white lead to suit.

Snuff Color. French ocher for base; add burnt umber and a bit of Venetian red.

Straw Color. Medium chrome yellow for base; add French ocher; a bit of venetian red; lighten up with white lead.

Stone Color and Yellow Drabs. White lead for base; add French ocher; tinge up with medium chrome yellow and burnt umber. By varying quantities all shades of yellow drabs can be made.

Tan. White lead for base; add burnt sienna and a trifle of lamp black.

Tally-Ho. White lead for base; add French ocher; Venetian red; dark chrome green with a bit of ivory black.

Terra Cotta. French ocher for base; add Venetian red and white lead. Some shades of it require the addition of Indian red. Some rich shades are sometimes desired under that name; use orange chrome yellow in place of French ocher, add Venetian red and a trifle of burnt umber to suit.

Turquoise Blue. White lead for base, or better, zinc white; add cobalt blue; Paris green or pale chrome green.

Vienna Brown. Burnt umber for base; add Venetian red; French ocher; and lighten with white lead to suit.

Violet. White lead for base; add pale Indian red, and a trifle of dark Indian red.

Willow Green. White lead for base; add sufficient medium chrome yellow to make a pretty deep shade; then add a small quantity of raw umber and ivory black.

Wine Color. English vermillion or scarlet-toned vermillion red for base; add madder lake or carmine; ultramarine blue; ivory black.

Another way; dark Tuscan red of good quality to which add a trifle of ivory black.

Water Green. White lead for base; add raw sienna; dark chrome green.

Yellow Bronze. Lemon or medium chrome yellow for base; add French ocher and just a trifle of burnt umber.

INDEX

A.

Acacia, 246.
Acorn brown, 246.
Adulterants of white lead, 25.
Adulteration of chrome yellow, 79.
Alabaster, 246.
Alderney brown, 246.
Alizarin, 120.
Aluminous ocher, 58.
Amaranth, 246.
Amber brown, 246.
American ochers, 70, 183.
American sienna, 187.
American umber, 187.
American vermillion, 104, 184.
American zinc, 25.
Analysis of Oxford ocher, 65.
Analysis of terre verte, 140.
Analysis of umber, 162.
Anemone, 246.
Antique bronze, 246.
Antwerp blue, 187.
Apple green, 246.
Apricot, 246.
Armenian red, 246.
Artificial ocher, 183.
Ash gray, 246.
Ashes of roses, 246.
Asiatic bronze, 246.
Aureolin; 87, 183.
 properties of, 87.
Aurora yellow, 184.
Autumn leaves, 246.

Azure blue, 247.
Azurite, 187.

B.

Barium chromate, 183.
Baryta lemon yellow, 78, 183.
 properties of, 78.
Baryta white, 51, 183.
 composition of, 51.
 properties of, 52.
 source of supply of, 51.
 uses as an adulterant, 53.
Baryta white artificially made,
 54.
 as a distemper color, 55.
Baryta yellow, 183.
Barytes, 183.
Base (the) in mixing tints, 237.
Basic copper acetate, 145, 186.
Bay, 247.
Beeswax, 217.
Begonia, 247.
Benzine, 208.
 properties of, 208.
 uses of, 209.
Berg blau, 187.
Berg grün, 186.
Berlin blue, 187.
Best vehicle for white lead, 22.
Bice, 187.
Bismark brown, 247.
Black lead (see graphite), 188.
Black pigments, 170.
Black pigments, 188.

- Black slate, 247.
 Blanc d'argent, 182.
 Blanc de plomb, 182.
 Blanc de zinc, 182.
 Blanc fixe, 183.
 Bleu d'azur, 186
 Bleu de Berlin, 187.
 Bleu de cobalt, 187.
 Bleu de smalte, 187.
 Bleu de Thenard, 187.
 Bleu d'outremer, 186.
 Blow pipe test for white lead, 29.
 how to make, 30.
 Blue black (see charcoal black), 188.
 Blue pigments, 186.
 Blue smalt, 155.
 properties, 155.
 Blue verditer, 154, 187.
 production of, 154.
 properties of, 154.
 Boiled linseed oil, 203, 231.
 adulterations of, 231.
 properties of, 231.
 uses of, 231.
 Bordeaux blue, 247.
 Bottle green, 247.
 Brass, 247.
 Brick color, 247.
 Bronze green, 247.
 Bronze red, 247.
 Bronze yellow, 247.
 Brown ocher, 183.
 Brown pigments, 187.
 Brown pink, 184.
 Brown stone, 247.
 Browns, 247.
 Brun de Vandyke, 188.
 Burnt ocher, 184.
 Burnt sienna, 187.
 Burnt umber, 159, 187.
 properties of, 159.
 uses of, 159.
 Buttercup, 247.
- C.
- Cadmium, 92.
 chemistry of, 92.
 properties of, 92.
 Cadmium gelb, 184.
 Cadmium yellow, 184.
 Café au lait, 248.
 Cambridge red, 248.
 Canary, 248.
 Caput motuum vitrioli, 184.
 Carbonate of lime (see whiting), 41, 182.
 Carbon black (see gas black), 188.
 Carmin, 184.
 Carmin de garance, 185.
 Carmin lack, 185.
 Carmine, 127, 185.
 history of, 127.
 properties of, 127.
 uses of, 127.
 Carnation, 248.
 Cassel earth, 188.
 Cendres blues, 187.
 Cerulean blue, 187, 248.
 Ceruleum, 153, 187.
 properties of, 153.
 uses of, 153.
 Ceruse, 153.
 Chalking of white lead, 21.
 Chamois, 248.
 Chamoline, 248.
 Charcoal black, 187, 188.
 preparation of, 178.
 properties of, 178.
 uses of, 178.
 Chartreuse, 248.
 Cherry red, 248.
 Chessylite, 154, 187.
 Chestnut, 248.
 China clay (see kaolin), 183.
 Chinese blue, 150, 186.
 properties of, 150.
 uses of, 150.
 Chinese vermillion, 184.
 Chinese white, 182.

Chocolate, 248.
Chromate of lead, 183, 184.
Chrome, 183.
Chrome green, 129, 185.
chemistry of, 129.
manufacture of, 130.
properties of, 132.
proprietary names for, 131.
uses of, 133.
Chrome jaune, 183.
Chrome yellows, 73, 183.
chemistry of, 74.
general remarks on, 73.
manufacture of, 74.
medium, 74.
properties of, 74.
canary and lemon, 75, 183.
manufacture of, 75.
orange, 75, 183.
defects of, 77.
manufacture of, 75, 183.
properties of, 76.
uses of, 77.
Chrom gelb, 183.
Chromium sesquioxide, 186.
Cinnabar, 184.
Cinnamon, 248.
Citrine lake, 184.
Citron, 249.
Claret, 248.
Clay bank, 248.
Clay drab, 248.
Cobalt blue, 248.
Cobalt blue, 152, 187.
manufacture of, 152.
properties of, 152.
uses of, 152.
Cobalt green, 135, 185.
properties of, 135.
uses of, 135.
Cobalt yellow, (see aureolin), 183.
Cocoanut brown, 249.
Coelin, 187.
Coelin blue, 187.
Colcothar, 184.

Collen earth, 188.
Cologne earth, 188.
Colonial yellow, 249.
Coloring pigments for tints, 235.
Compounding of pigments, 187.
Copper, 249.
Coral pink, 248.
Cotrine, 249.
Cream color, 249.
Cremser weiss, 182.
Crimson, 249.
Crocus, 184.
Cupric arsenite, 186.
Cyprus umber, 187.

D.

Dahl process white lead, 27.
manufacture of, 28.
properties of, 28.
Dark chrome green, 185.
Dextrin, 226.
properties of, 226.
Dove color, 249.
Dregs of wine, 249.
Drop black (see ivory black),
175, 188.
Dryers, 229.
general remarks on, 229.
lead oxides as driers, 232.
oxides of manganese, 232.
paste form, 233.
Dumont's blue, 187.
Dunkel gelb lack, 184.
Dutch pink, 90, 184.
character of, 90.
properties of, 91.
Dutch process white lead, 9.
chemistry of, 11.
corroding of, 10.

E.

Earth whites, 40.
general remarks, 40.

- Ecru, 249.
 Egyptian green, 249.
 Electric blue, 249.
Elfenbein schwartz, 188.
 Emerald, 249.
 Emerald green (see Paris green), 143.
 Emerald oxide of chromium, 186.
 English ochers, 69.
 English umber, 187.
 English vermillion (see vermilion), 184.
 Extra light chrome green, 185.
- F.
- Fawn, 249.
 Fixed oils, 189.
 Flake white, 22, 182.
 Flaxseed oil (see linseed oil), 189.
 Flesh color, 249.
 Floated barytes, 183.
 Frankfort black, 188.
Frankfurter schwartz, 188.
 French blue, 186.
 French gray, 250.
 French ocher, 183.
 French red, 250.
 French zinc, 34.
- G.
- Gamboge, 86, 183.
 properties of, 86.
 Gas black, 173, 188.
 properties of, 173.
 uses of, 174.
 Gazelle, 250.
 Gelben ocher, 183.
 Geranium, 250.
 Giallo di napoli, 186.
 Glues, 220.
 general remarks on, 220.
 properties of, 221.
 uses of, 222.
- H.
- Glycerine, 228.
 properties of, 228.
 uses of, 228.
 Gmelin's blue, 186.
 Gobelin blue, 250.
 Gold, 250.
 Golden brown, 250.
 Gommegutte, 183.
 Graphite, 179, 188.
 production of, 179.
 properties of, 180.
 Grass green, 250.
 Gray drabs, 250.
 Gray green, 250.
 Gray stone, 250.
 Green bice, 186.
 Green carbonate of copper, 186.
 Green earth, 186.
 Green oxide of chromium, 134, 186.
 properties of, 134.
 uses of, 134.
 Green pigments, 129, 185.
 Green stone, 250.
 Green verditer, 142, 186.
 properties of, 142.
 Greys, 250.
 Grinding colors, a trade, 68.
 Grün erde, 186.
 Grünes chromoxyd, 186.
 Grüns pan, 186.
 Guimet's blue, 186.
 Gum arabic, 224.
 properties of, 224.
 uses of, 225.
 Gypsum, 46, 183.
 chemistry of, 47.
 history of, 46.
 properties of, 47.
 source of supply, 46.
- Hay color, 250.
 Heavy spar, 183.

Heliotrope, 250.
 History of white lead, 9.
 Honey, 227.
 properties of, 227.

I.

Imitation vermillion, 100, 184.
 Impurities in linseed oil, 201.
 properties of, 126.
 tests for, 201.
 uses of, 126.
 Indian brown, 250.
 Indian lake, 126, 185.
 Indian pink, 250.
 Indian reds, 110.
 characteristics of, 110.
 production of, 110.
 properties of, 112.
 uses of, 112.

Indian yellow, 87, 183.
 chemistry of, 88.
 properties of, 88.
 Indisch gelb, 183.
 Iron gray, 250.
 Italian pink, 184.
 Italian sienna, 187.
 Ivory black, 175, 188.
 manufacture of, 175.
 properties of, 176.
 uses of, 176.
 Ivy green, 251.

J.

Japans, 214.
 properties of, 214.
 uses of, 214.
 Jasper, 251.
 Jaune brilliant, 184.
 Jaune d'antimoine, 184.
 Jaune de cadmium, 184.
 Jaune de cobalt, 183.
 Jaune de Mars, 183.
 Jaune de Naples, 184.
 Jaune Indien, 183.
 Jaune royal, 184.
 Jonquil, 251.

K.

Kaolin, 44, 183.
 properties of, 45.
 King's yellow, 93, 184.
 characteristics of, 93.
 chemistry of, 94.
 Kobalt blau, 187.
 Kobalt gelb, 183.
 Kobalt grün, 185.
 Konig's gelb, 184.
 Krapp lack, 185.

L.

Lac lake, 185.
 Lack lack, 185.
 Lakes, 118.
 general remarks on, 118.
 manufacture of, 121.
 red lakes, 119.
 Lamp black, 170.
 chemistry of, 170.
 manufacture of, 170.
 properties of, 171.
 uses of, 172.
 Lapis lazuli blau, 186.
 Laque brown, 183.
 Laque cramoisi, 185.
 Laque de garance, 185.
 Laque d'Inde, 185.
 Lavender, 251.
 Lazurstein blau, 186.
 Lead color, 251.
 Lead (sulphate), see sulphate of lead, 26.
 Lead (sublimed), see sublimed lead, 27.
 Lead (white), see white lead, 9.
 Lead (white oxide), see white oxide of lead, 28.
 Leaf buds, 251.
 Leather, 251.
 Lemon, 251.
 Levant umber, 187.
 Lilac, 251.

Linseed oil, 191.
 boiled, 203.
 chemistry of, 195.
 drying of, 196.
 manufacture of, 191.
 properties of, 198.
 tests for impurities, 201.
 uses of, 199.
 Liquid dryers, 231.
 general remarks on, 231.
 List of principal tints, 243.
 London smoke, 251.

M.

Madder brown, 185.
 Madder lakes, 123, 185.
 properties of, 124.
 uses of, 124.
 Madder purple, 185.
 Madder red, 185.
 Magenta, 251.
 Malachite, 142.
 Manilla or deck paint, 251.
 Marigold, 251.
 Maroon, 251.
 Mars gelb, 183.
 Mars orange, 183.
 Mars yellow, 183.
 Mastic, 251.
 Mauve, 251.
 Medium chrome green, 185.
 Medium chrome yellow, 183.
 Metallic browns, 166.
 manufacture of, 166.
 properties of, 167.
 uses of, 167.
 Mexican red, 251.
 Mignonette, 251.
 Miltos, 185.
 Mineral yellow, 183.
 Mittes green, 186.
 Mittler's green, 186.
 Mixing compound tints, 239.
 general remarks on, 243.
 how to prepare, 240.

Mixing compound tints — *cont'd.*
 in distemper, 241.
 Mixing simple tints, 239.
 Molasses (see honey), 227.
 Moorish red, 252.
 Mortar colors made from ochers,
 75.
 Moss color, 252.
 Mouse color, 252.
 Mountain blue, 187.
 Mountain green, 186.
 Mulberry, 252.
 Myrtle green, 252.

N.

Naphtha (see benzine), 208.
 Naples yellow, 89, 184.
 chemistry of, 89.
 history of, 89.
 properties of, 89.
 Neapel gelb, 89.
 Neutral tints, 236.
 New blue, 186.
 Nile blue, 252.
 Noir de fumée, 188.
 Noir d'ivoire, 188.
 Noir de vigne, 188.
 Normandy blue, 252.
 Nut brown, 252.

O.

Oak color, 252.
 Ocher jaune, 183.
 Ocher roth, 185.
 Ocher rouge, 185.
 Ochers, 57, 183.
 aluminous, 59.
 analysis of Oxford, 65.
 chemical properties, 58.
 general characteristics, 58.
 grinding in oil, 67.
 mining of, 61.
 properties of, 61.
 silicate, 58.
 uses of, 63.
 Oil of turpentine, 207.

- Old gold, 252.
Olive, 252.
Olive brown, 252.
Opal gray, 253.
Opaque oxide of chromium, 186.
Orange, 252.
Orange brown, 252.
Orange cadmium, 184.
Orange chrome yellow, 183.
Orient yellow, 184.
Oriental green, 252.
Orpiment (see king's yellow), 184.
Oxford ocher, 183.
Oxide of zinc (see zinc white), 182.
- P.
- Paraffin waxes, 219.
 characteristics of, 219.
Pariser blau, 187.
Paris green, 143.
 chemistry of, 143.
 preparation of, 143.
 uses of, 143.
Paris white, 182.
Peach blossom, 253.
Peacock blue, 253.
Pea green, 253.
Pearl, 253.
Peori, 183.
Permanent blue, 186.
Permanent weiss, 183.
Permanent white, 183.
Permanent yellow, 183.
Persian orange, 253.
Pigment, definition of, 2.
Pink, 253.
Pink madder lake, 185.
Pistache, 253.
Plumbago, 188.
Plum color, 253.
Pompeian red, 253.
Poppyseed oil, 204.
 properties of, 204.
 uses of, 204.
Portland stone, 253.
- Powdered silica, 183.
Preface, iii.
Preliminary remarks, i.
Primary colors, 235.
Primrose, 253.
Prussian blue, 148, 187.
 history of, 148.
 manufacture of, 148.
 properties of, 149.
 uses of, 149.
Prussiate of iron, 187.
Puiri, 183.
Pulp ground white lead, 16.
Puree, 183.
Purple, 253.
Purple brown, 253.
Purple lake, 185.
Purpurin, 120.
- Q.
- Quaker green, 253.
Quercitron lake, 184.
- R.
- Raw sienna, 163, 187.
Raw umber, 156, 187.
Red chalk, 185.
Red hematite, 185.
Red iron ore, 185.
Red lead, 116.
 chemistry of, 116.
 history of, 116.
 properties of, 117.
 uses of, 117.
Red ocher, 185.
Red oxide of iron, 114.
 properties of, 114.
 uses of, 115.
Red pigments, 95.
Rinkman's green, 185.
Roan, 253.
Robin's egg blue, 254.
Roman ocher, 185.
Rose lake, 123.
 properties of, 123.
 uses of, 123.

Rose madder lake, 185.

Rose pink, 122.

 properties of, 122.

 uses of, 122.

Rouge, 184.

Rouge de Venise, 184.

Royal blue, 155, 187.

Ruben's madder, 185.

Rubrica, 185.

Ruddle, 185.

Russ, 188.

Russet, 254.

Russian gray, 254.

S.

Sage green, 254.

Salmon, 254.

Sap green, 254.

Sapphire blue, 254.

Saxon blue, 187.

Scale test for adulterations:

 how to make it, 81.

 in colors, 80.

Scarlet, 254.

Scarlet ocher, 185.

Scheele's green, 144, 186.

 characteristics of, 144.

Scheele's grün, 186.

Sea green, 254.

Seal brown, 254.

Secondary colors, 235.

Shellac (alcoholic solution), 215.

 properties of, 215.

 uses of, 215.

Shrimp pink, 254.

Siccatives (see driers), 229.

Sienna erde, 187.

Siennas, 161, 187.

 analysis of, 162.

 burnt sienna, 163.

 properties of, 164.

 uses of, 164.

 chemistry of, 162.

 general characteristics, 161.

 history of, 161.

Siennas—*continued*.

 properties of, 163.

 raw sienna, 163.

 properties of, 163.

 uses of, 163.

Silicate earth, 48.

 chemistry of, 49.

 properties of, 49.

Silver white, 182.

Silver white, 183.

Sky blue, 254.

Slate, 254.

Smalt, 187.

Smalte, 187.

Snuff color, 254.

Soluble blue (see Chinese blue),

 150, 186.

Spanish brown, 168.

 properties of, 168.

 uses of, 168.

Spanish white, 182.

Spirits of turpentine, 207.

 manufacture of, 207.

Starch, 226.

 properties of, 226.

Stone color, 254.

Straw color, 254.

Strictly pure vs. compound leads,

 24.

Sublimed lead, 27.

 properties of, 27.

Sugar (see honey), 227.

Sulphate of barium, 183.

Sulphate of lead, 20.

 chemistry of, 26.

 properties of, 26.

Sulphate of lime (see whiting),

 182.

Sulphide of cadmium, 184.

System of packing white lead, 23.

T.

Table of synonyms, 181.

Tally-ho, 255.

Tan, 254.

Terra-cotta, 255.

Terra di sienna, 187.

Terra ombra, 187.

Terra rosa, 187.

Terra verde, 186.

Terre d'ombre, 187.

Terre de sienne, 187.

Terre de verone, 186.

Terre verte, 139, 186.

analysis of, 139.

history of, 139.

production of, 139.

uses of, 139.

Tertiary colors, 236.

Turkey umber, 156, 187.

Turner's blue, 187.

Turquoise blue, 255.

Tuscan reds, 112.

manufacture of, 112.

properties of, 113.

uses of, 113.

U.

Ultramarine blue, 145, 186.

chemistry of, 145.

manufacture of, 145.

properties of, 146.

uses of, 146.

Umbers, 156, 187.

burnt umber, 159.

properties of, 159.

chemistry of, 157.

properties of, 158.

provenances of, 156.

raw umber, 156.

burnt umber, 159.

properties of, 156.

uses of, 158.

Umbräun, 187.

V.

Vandyke brown, 165, 188.

properties of, 165.

provenance of, 165.

Vandyke brown—*continued*.

uses of, 165.

Varnishes, 210.

general remarks, 210.

properties of, 211.

uses of, 212.

Vegetable waxes, 217.

characteristics of, 217.

Vehicles for mixing pigments, 189.

Venetian red, 106, 184.

history of, 106.

manufacture of, 107.

properties of, 109.

uses of, 109.

Verdigris, 141, 188.

chemistry of, 141.

properties of, 141.

uses of, 141.

Vermilion, 95, 184.

characteristics of, 98.

chemistry of, 96.

history of, 95.

source of supply, 95.

uses of, 99.

Vermilion reds, 100, 184.

manufacture of, 101.

properties of, 103.

uses of, 103.

Vert emeraude, 186.

Vert de chrome, 186.

Vert de cobalt, 185.

Vert de gris, 186.

Vert de Guimet, 186.

Vert de Montpellier, 186.

Vert de Scheele, 186.

Vert de zinc, 185.

Vert Panetier, 186.

Vert Paul Verone, 186.

Vienna brown, 255.

Vine black, 188.

Violet, 255.

Viridian, 137, 186.

properties of 137.

uses of, 137.

Volatile oils, 206.

W.

- Water green, 255.
 Waxes, 217.
 White lead, 9.
 chalking of, 21.
 chemistry of, 11.
 cylinder system of corrosion, 18.
 defects of, 21.
 Dutch process of corroding, 10.
 grinding dry in oil, 15.
 history of, 9.
 injurious gases, 22.
 manufacture by, 12.
 process of manufacture, 19.
 properties of, 20.
 pulp ground lead, 16.
 ripening oil ground lead, 16.
 stack system of corrosion, 11.
 vehicles for, 22.
 volatile oils for, 22.
 working qualities, 20.
 White oxide of lead, 28.
 hardening in package when
 ground in oil, 28.
 White pigments, 8.
 White silicate, 183.
 Whiting, 41, 182.
 chemistry of, 42.
 levigation of, 42.

Whiting — *continued*.
 mining of, 42.
 properties of, 43.
 qualities of, 43.
 source of, 42.

Willow green, 255.
 Wine color, 255.

Y.

Yellow bronze, 255.
 Yellow lake, 184.
 Yellow madder, 184.
 Yellow ocher, 57, 183.
 Yellow pigments, 57, 73, 183.
 Yellow ultramarine, 183.

Z.

Zaffre, 187.
 Zinc green, 135, 185.
 Zinc Weiss, 182.
 Zinc white, 32, 182.
 chemistry of, 33.
 compounds of, 38.
 defects of, 37.
 history of, 32.
 in distemper, 39.
 manufacture of, 33.
 properties of, 36.
 tests for purity of, 35.
 Zunzober, 184.



SHORT-TITLE CATALOGUE
OF THE
PUBLICATIONS
OF
JOHN WILEY & SONS,
NEW YORK.
LONDON: CHAPMAN & HALL, LIMITED.

ARRANGED UNDER SUBJECTS.

Descriptive circulars sent on application. Books marked with an asterisk (*) are sold at *net* prices only. All books are bound in cloth unless otherwise stated.

AGRICULTURE.

Armsby's Manual of Cattle-feeding.....	12mo, \$1 75
Principles of Animal Nutrition.....	8vo, 4 00
Budd and Hansen's American Horticultural Manual:	
Part I. Propagation, Culture, and Improvement.....	12mo, 1 50
Part II. Systematic Pomology.....	12mo, 1 50
Elliott's Engineering for Land Drainage.....	12mo, 1 50
Practical Farm Drainage.....	12mo, 1 00
Graves's Forest Mensuration.....	8vo, 4 00
Green's Principles of American Forestry.....	12mo, 1 50
Grotenfelt's Principles of Modern Dairy Practice. (Woll.).....	12mo, 2 00
Hanausek's Microscopy of Technical Products. (Winton.).....	8vo, 5 00
Herrick's Denatured or Industrial Alcohol.....	8vo, 4 00
Maynard's Landscape Gardening as Applied to Home Decoration.....	12mo, 1 50
* McKay and Larsen's Principles and Practice of Butter-making.....	8vo, 1 50
Sanderson's Insects Injurious to Staple Crops.....	12mo, 1 50
* Schwarz's Longleaf Pine in Virgin Forest	12mo, 1 25
Stockbridge's Rocks and Soils.....	8vo, 2 50
Winton's Microscopy of Vegetable Foods.....	8vo, 7 50
Woll's Handbook for Farmers and Dairymen.....	16mo, 1 50

ARCHITECTURE.

Baldwin's Steam Heating for Buildings.....	12mo, 2 50
Bashore's Sanitation of a Country House.....	12mo, 1 00
Berg's Buildings and Structures of American Railroads.....	4to, 5 00
Birkmire's Planning and Construction of American Theatres.....	8vo, 3 00
Architectural Iron and Steel.....	8vo, 3 50
Compound Riveted Girders as Applied in Buildings.....	8vo, 2 00
Planning and Construction of High Office Buildings.....	8vo, 3 50
Skeeton Construction in Buildings.....	8vo, 3 00
Brigg's Modern American School Buildings.....	8vo, 4 00
Carpenter's Heating and Ventilating of Buildings.....	8vo, 4 00

Freitag's Architectural Engineering.....	8vo.	3 50
Fireproofing of Steel Buildings.....	8vo.	2 50
French and Ives's Stereotomy.....	8vo.	2 50
Gerhard's Guide to Sanitary House-inspection.....	16mo,	1 00
Sanitation of Public Buildings.....	12mo,	1 50
Theatre Fires and Panics.....	12mo,	1 50
*Greene's Structural Mechanics.....	8vo.	2 50
Holly's Carpenters' and Joiners' Handbook.....	18mo,	75
Johnson's Statics by Algebraic and Graphic Methods.....	8vo.	2 00
Kellaway's How to Lay Out Suburban Home Grounds.....	8vo.	2 00
Kidder's Architects' and Builders' Pocket-book. Rewritten Edition. 16mo, mor.,	5 00	
Merrill's Stones for Building and Decoration.....	8vo.	5 00
Non-metallic Minerals: Their Occurrence and Uses.....	8vo.	4 00
Monckton's Stair-building.....	4to,	4 00
Patton's Practical Treatise on Foundations.....	8vo.	5 00
Peabody's Naval Architecture.....	8vo.	7 50
Rice's Concrete-block Manufacture.....	8vo.	2 00
Richey's Handbook for Superintendents of Construction.....	16mo, mor.,	4 00
* Building Mechanics' Ready Reference Book:		
* Carpenters' and Woodworkers' Edition.....	16mo, morocco,	1 50
* Cementworkers and Plasterer's Edition. (In Press.)		
* Stone- and Brick-mason's Edition.....	12mo, mor.,	1 50
Sabin's Industrial and Artistic Technology of Paints and Varnish.....	8vo.	3 00
Siebert and Biggin's Modern Stone-cutting and Masonry.....	8vo.	1 50
Snow's Principal Species of Wood.....	8vo.	3 50
Sondericker's Graphic Statics with Applications to Trusses, Beams, and Arches.		
	8vo,	2 00
Towne's Locks and Builders' Hardware.....	18mo, morocco,	3 00
Turneaure and Maurer's Principles of Reinforced Concrete Construction.....	8vo.	3 00
Wait's Engineering and Architectural Jurisprudence.....	8vo,	6 00
	Sheep,	6 50
Law of Operations Preliminary to Construction in Engineering and Architecture.....	8vo,	5 00
	Sheep,	5 50
Law of Contracts.....	8vo,	3 00
Wilson's Air Conditioning, (In Press.)		
Wood's Rustless Coatings: Corrosion and Electrolysis of Iron and Steel. 8vo,	4 00	
Worcester and Atkinson's Small Hospitals, Establishment and Maintenance, Suggestions for Hospital Architecture, with Plans for a Small Hospital.		
	12mo,	1 25
The World's Columbian Exposition of 1893.....	Large 4to,	1 00

ARMY AND NAVY.

Bernadou's Smokeless Powder, Nitro-cellulose, and the Theory of the Cellulose Molecule.....	12mo,	2 50
Chase's Screw Propellers and Marine Propulsion.....	8vo,	3 00
Cloke's Gunner's Examiner.....	8vo,	1 50
Craig's Azimuth.....	4to,	3 50
Crehore and Squier's Polarizing Photo-chronograph.....	8vo,	3 00
* Davis's Elements of Law.....	8vo,	2 50
* Treatise on the Military Law of United States.....	8vo,	7 00
	Sheep,	7 50
De Brack's Cavalry Outposts Duties. (Carr.).....	24mo, morocco,	2 00
Dietz's Soldier's First Aid Handbook.....	16mo, morocco,	1 25
* Dudley's Military Law and the Procedure of Courts-martial. Large 12mo,	2 50	
Durand's Resistance and Propulsion of Ships.....	8vo,	5 00

* Dyer's Handbook of Light Artillery.....	12mo, 3 00
Eissler's Modern High Explosives.....	8vo, 4 00
* Fiebeger's Text-book on Field Fortification.....	Small 8vo, 2 00
Hamilton's The Gunner's Catechism.....	18mo, 1 00
* Hoff's Elementary Naval Tactics.....	8vo, 1 50
Ingalls's Handbook of Problems in Direct Fire.....	8vo, 4 00
* Lissak's Ordnance and Gunnery.....	8vo, 6 00
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I and II.	8vo, each, 6 00
* Mahan's Permanent Fortifications. (Mercur.).	8vo, half morocco, 7 50
Manual for Courts-martial.....	16mo, morocco, 1 50
* Mercur's Attack of Fortified Places.....	12mo, 2 00
* Elements of the Art of War.....	8vo, 4 00
Metcalf's Cost of Manufactures—And the Administration of Workshops.	8vo, 5 00
* Ordnance and Gunnery. 2 vols.	12mo, 5 00
Murray's Infantry Drill Regulations.....	18mo, paper, 10
Nixon's Adjutants' Manual.....	24mo, 1 00
Peabody's Naval Architecture.....	8vo, 7 50
* Phelps's Practical Marine Surveying.....	8vo, 2 50
Powell's Army Officer's Examiner.....	12mo, 4 00
Sharpe's Art of Subsisting Armies in War.....	18mo, morocco, 1 50
* Tupes and Poole's Manual of Bayonet Exercises and Musketry Fencing.	24mo, leather, 50
Weaver's Military Explosives.....	8vo, 3 00
Wheeler's Siege Operations and Military Mining.....	8vo, 2 00
Winthrop's Abridgment of Military Law.....	12mo, 2 50
Woodhull's Notes on Military Hygiene.....	16mo, 1 50
Young's Simple Elements of Navigation.....	16mo, morocco, 2 00

ASSAYING.

Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe.	
12mo, morocco, 1 50	
Furman's Manual of Practical Assaying.....	8vo, 3 00
Lodge's Notes on Assaying and Metallurgical Laboratory Experiments.....	8vo, 3 00
Low's Technical Methods of Ore Analysis.....	8vo, 3 00
Miller's Manual of Assaying.....	12mo, 1 00
Cyanide Process.....	12mo, 1 00
Minet's Production of Aluminum and its Industrial Use. (Waldo.).	12mo, 2 50
O'Driscoll's Notes on the Treatment of Gold Ores.....	8vo, 2 00
Ricketts and Miller's Notes on Assaying.....	8vo, 3 00
Robine and Lenglen's Cyanide Industry. (Le Clerc.).	8vo, 4 00
Ulke's Modern Electrolytic Copper Refining.....	8vo, 3 00
Wilson's Cyanide Processes.....	12mo, 1 50
Chlorination Process.....	12mo, 1 50

ASTRONOMY.

Comstock's Field Astronomy for Engineers.....	8vo, 2 50
Craig's Azimuth.....	4to, 3 50
Crandall's Text-book on Geodesy and Least Squares.....	8vo, 3 00
Doolittle's Treatise on Practical Astronomy.....	8vo, 4 00
Gore's Elements of Geodesy.....	8vo, 2 50
Hayford's Text-book of Geodetic Astronomy.....	8vo, 3 00
Merriman's Elements of Precise Surveying and Geodesy.....	8vo, 2 50
* Michie and Harlow's Practical Astronomy.....	8vo, 3 00
* White's Elements of Theoretical and Descriptive Astronomy.....	12mo, 2 00

BOTANY.

Davenport's Statistical Methods, with Special Reference to Biological Variation.		
	16mo, morocco,	1 25
Thomé and Bennett's Structural and Physiological Botany.....	16mo,	2 25
Westermayer's Compendium of General Botany. (Schneider.)......	8vo,	2 00

CHEMISTRY.

* Abegg's Theory of Electrolytic Dissociation. (Von Ende.).....	12mo,	1 25
Adriance's Laboratory Calculations and Specific Gravity Tables.....	12mo,	1 25
Alexeyeff's General Principles of Organic Synthesis. (Matthews.).....	8vo,	3 00
Allen's Tables for Iron Analysis.....	8vo,	3 00
Arnold's Compendium of Chemistry. (Mandel)......	Small 8vo,	3 50
Austen's Notes for Chemical Students.....	12mo,	1 50
Beard's Mine Gases and Explosions. (In Press.)		
Bernadou's Smokeless Powder.—Nitro-cellulose, and Theory of the Cellulose Molecule.....	12mo,	2 50
Bolduan's Immune Seria.....	12mo,	1 50
* Browning's Introduction to the Rarer Elements.....	8vo,	1 50
Brush and Penfield's Manual of Determinative Mineralogy.....	8vo,	4 00
* Claassen's Beet-sugar Manufacture. (Hall and Rolfe.)......	8vo,	3 00
Clasen's Quantitative Chemical Analysis by Electrolysis. (Boltwood.).8vo,	3 00	
Cohn's Indicators and Test-papers.....	12mo,	2 00
Tests and Reagents.....	8vo,	3 00
Crafts's Short Course in Qualitative Chemical Analysis. (Schaeffer.).12mo,	1 50	
* Danneel's Electrochemistry. (Merriam.)......	12mo,	1 25
Dolezalek's Theory of the Lead Accumulator (Storage Battery). (Von Ende.)......	12mo,	2 50
Drechsel's Chemical Reactions. (Merrill.)......	12mo,	1 25
Duhem's Thermodynamics and Chemistry. (Burgess.)......	8vo,	4 00
Eissler's Modern High Explosives.....	8vo,	4 00
Effront's Enzymes and their Applications. (Prescott.).....	8vo,	3 00
Erdmann's Introduction to Chemical Preparations. (Dunlap.)......	12mo,	1 25
* Fischer's Physiology of Alimentation.....	Large 12mo,	2 00
Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe.12mo, morocco,	1 50	
Fowler's Sewage Works Analyses.....	12mo,	2 00
Fresenius's Manual of Qualitative Chemical Analysis. (Wells.).8vo,	5 00	
Manual of Qualitative Chemical Analysis. Part I. Descriptive. (Wells.).8vo,	3 00	
Quantitative Chemical Analysis. (Cohn.) 2 vols.....	8vo,	12 50
Fuertes's Water and Public Health.....	12mo,	1 50
Furman's Manual of Practical Assaying.....	8vo,	3 00
* Getman's Exercises in Physical Chemistry.....	12mo,	2 00
Gill's Gas and Fuel Analysis for Engineers.....	12mo,	1 25
* Gooch and Browning's Outlines of Qualitative Chemical Analysis. Small 8vo,	1 25	
Grotenfelt's Principles of Modern Dairy Practice. (Woll.)......	12mo,	2 00
Groth's Introduction to Chemical Crystallography (Marshall).....	12mo,	1 25
Hammarsten's Text-book of Physiological Chemistry. (Mandel).8vo,	4 00	
Hanausek's Microscopy of Technical Products. (Winton.).8vo,	5 00	
* Haskin's and MacLeod's Organic Chemistry.....	12mo,	2 00
Helm's Principles of Mathematical Chemistry. (Morgan.)......	12mo,	1 50
Hering's Ready Reference Tables (Conversion Factors).16mo, morocco,	2 50	
Herrick's Denatured or Industrial Alcohol.....	8vo,	4 00
Hind's Inorganic Chemistry.....	8vo,	3 00
* Laboratory Manual for Students.....	12mo,	1 00
Holleman's Text-book of Inorganic Chemistry. (Cooper.).8vo,	2 50	
Text-book of Organic Chemistry. (Walker and Mott.).8vo,	2 50	
* Laboratory Manual of Organic Chemistry. (Walker.).12mo,	1 00	

Holley and Ladd's Analysis of Mixed Paints, Color Pigments, and Varnishes. (In Press)	
Hopkins's Oil-chemists' Handbook.....	.8vo, 3 00
Iddings's Rock Minerals.....	.8vo, 5 00
Jackson's Directions for Laboratory Work in Physiological Chemistry. .8vo, 1 25	
Johannsen's Key for the Determination of Rock-forming Minerals in Thin Sections. (In Press)	
Keep's Cast Iron.....	.8vo, 2 50
Ladd's Manual of Quantitative Chemical Analysis.....	12mo, 1 00
Landauer's Spectrum Analysis. (Tingle). .8vo, 3 00	
* Langworthy and Austen. The Occurrence of Aluminium in Vegetable Products, Animal Products, and Natural Waters.....	.8vo, 2 00
Lassar-Cohn's Application of Some General Reactions to Investigations in Organic Chemistry. (Tingle). .12mo, 1 00	
Leach's The Inspection and Analysis of Food with Special Reference to State Control.....	.8vo, 7 50
Löb's Electrochemistry of Organic Compounds. (Lorenz). .8vo, 3 00	
Lodge's Notes on Assaying and Metallurgical Laboratory Experiments. .8vo, 3 00	
Low's Technical Method of Ore Analysis.....	.8vo, 3 00
Lunge's Techno-chemical Analysis. (Cohn). .12mo, 1 00	
* McKay and Larsen's Principles and Practice of Butter-making.....	.8vo, 1 50
Maire's Modern Pigments and their Vehicles. (In Press.)	
Mandel's Handbook for Bio-chemical Laboratory.....	12mo, 1 50
* Martin's Laboratory Guide to Qualitative Analysis with the Blowpipe. .12mo, 60	
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.) 3d Edition, Rewritten.....	.8vo, 4 00
Examination of Water. (Chemical and Bacteriological). .12mo, 1 25	
Matthew's The Textile Fibres. 2d Edition, Rewritten8vo, 4 00
Meyer's Determination of Radicles in Carbon Compounds. (Tingle). .12mo, 1 00	
Miller's Manual of Assaying.....	12mo, 1 00
Cyanide Process	12mo, 1 00
Minet's Production of Aluminum and its Industrial Use. (Waldo). .12mo, 2 50	
Mixer's Elementary Text-book of Chemistry.....	12mo, 1 50
Morgan's An Outline of the Theory of Solutions and its Results.....	12mo, 1 00
Elements of Physical Chemistry.....	12mo, 3 00
* Physical Chemistry for Electrical Engineers.....	12mo, 5 00
Morse's Calculations used in Cane-sugar Factories.....	16mo, morocco, 1 50
* Muir's History of Chemical Theories and Laws.....	.8vo, 4 00
Mulliken's General Method for the Identification of Pure Organic Compounds. Vol. I.....	Large 8vo, 5 00
O'Driscoll's Notes on the Treatment of Gold Ores.....	.8vo, 2 00
Ostwald's Conversations on Chemistry. Part One. (Ramsey). .12mo, 1 50 " " " " " Part Two. (Turnbull). .12mo, 2 00	
* Palmer's Practical Test Book of Chemistry.....	12mo, 1 00
* Pauli's Physical Chemistry in the Service of Medicine. (Fischer). .12mo, 1 25	
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests. 8vo, paper, 50	
Pictet's The Alkaloids and their Chemical Constitution. (Biddle). .8vo, 5 00	
Pinner's Introduction to Organic Chemistry. (Austen). .12mo, 1 50	
Poole's Calorific Power of Fuels.8vo, 3 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Reference to Sanitary Water Analysis.....	12mo, 1 25
* Reisig's Guide to Piece-dyeing.....	.8vo, 25 00
Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint. .8vo, 2 60	
Ricketts and Miller's Notes on Assaying.....	.8vo, 3 00
Rideal's Sewage and the Bacterial Purification of Sewage.....	.8vo, 4 00
Disinfection and the Preservation of Food.....	.8vo, 4 00
Riggs's Elementary Manual for the Chemical Laboratory.....	.8vo, 1 25
Robine and Lenglen's Cyanide Industry. (Le Clerc). .8vo, 4 00	

Ruddiman's Incompatibilities in Prescriptions.	8vo,	2 00
* Why's in Pharmacy.	12mo,	1 00
Sabin's Industrial and Artistic Technology of Paints and Varnish.	8vo,	3 00
Salkowski's Physiological and Pathological Chemistry. (Orndorff).	8vo,	2 50
Schimpf's Text-book of Volumetric Analysis.	12mo,	2 50
Essentials of Volumetric Analysis.	12mo,	1 25
* Qualitative Chemical Analysis.	8vo,	1 25
Smith's Lecture Notes on Chemistry for Dental Students.	8vo,	2 50
Spencer's Handbook for Chemists of Beet-sugar Houses.	16mo, morocco	3 00
Handbook for Cane Sugar Manufacturers.	16mo, morocco,	3 00
Stockbridge's Rocks and Soils.	8vo,	2 50
* Tillman's Elementary Lessons in Heat.	8vo,	1 50
* Descriptive General Chemistry.	8vo,	3 00
Treadwell's Qualitative Analysis. (Hall).	8vo,	3 00
Quantitative Analysis. (Hall).	8vo,	4 00
Turneaure and Russell's Public Water-supplies.	8vo,	5 00
Van Deventer's Physical Chemistry for Beginners. (Boltwood).	12mo,	1 50
* Walke's Lectures on Explosives.	8vo,	4 00
Ware's Beet-sugar Manufacture and Refining. Vol. I.	Small 8vo,	4 00
" " " " " Vol. II.	Small 8vo,	5 00
Washington's Manual of the Chemical Analysis of Rocks.	8vo,	2 00
Weaver's Military Explosives.	8vo,	3 00
Wehrenfennig's Analysis and Softening of Boiler Feed-Water.	8vo,	4 00
Wells's Laboratory Guide in Qualitative Chemical Analysis.	8vo,	1 50
Short Course in Inorganic Qualitative Chemical Analysis for Engineering Students.	12mo,	1 50
Text-book of Chemical Arithmetic.	12mo,	1 25
Whipple's Microscopy of Drinking-water.	8vo,	3 50
Wilson's Cyanide Processes.	12mo,	1 50
Chlorination Process.	12mo,	1 50
Winton's Microscopy of Vegetable Foods.	8vo,	7 50
Wulling's Elementary Course in Inorganic, Pharmaceutical, and Medical Chemistry.	12mo,	2 00

CIVIL ENGINEERING.

BRIDGES AND ROOFS. HYDRAULICS. MATERIALS OF ENGINEERING RAILWAY ENGINEERING.

Baker's Engineers' Surveying Instruments.	12mo,	3 00
Bixby's Graphical Computing Table.	Paper $19\frac{1}{2} \times 24\frac{1}{2}$ inches.	25
Breed and Hosmer's Principles and Practice of Surveying.	8vo,	3 00
* Burr's Ancient and Modern Engineering and the Isthmian Canal.	8vo,	3 50
Comstock's Field Astronomy for Engineers.	8vo,	2 50
* Cortell's Allowable Pressures on Deep Foundations.	12mo,	1 25
Crandall's Text-book on Geodesy and Least Squares.	8vo,	3 00
Davis's Elevation and Stadia Tables.	8vo,	1 00
Elliott's Engineering for Land Drainage.	12mo,	1 50
Practical Farm Drainage.	12mo,	1 00
* Fiebeger's Treatise on Civil Engineering.	8vo,	5 00
Flemer's Phototopographic Methods and Instruments.	8vo,	5 00
Folwell's Sewerage. (Designing and Maintenance).	8vo,	3 00
Freitag's Architectural Engineering. 2d Edition, Rewritten.	8vo,	3 50
French and Ives's Stereotomy.	8vo,	2 50
Goodhue's Municipal Improvements.	12mo,	1 50
Gore's Elements of Geodesy.	8vo,	2 50
* Hauch and Rice's Tables of Quantities for Preliminary Estimates.	12mo,	1 25
Hayford's Text-book of Geodetic Astronomy.	8vo,	3 00

Hering's Ready Reference Tables (Conversion Factors).	16mo, morocco, 2	50
Howe's Retaining Walls for Earth.	12mo, 1	25
Hoyt and Grover's River Discharge.	8vo, 2	00
* Ives's Adjustments of the Engineer's Transit and Level.	16mo, Bds.	25
Ives and Hilt's Problems in Surveying.	16mo, morocco, 1	50
Johnson's (J. B.) Theory and Practice of Surveying.	Small 8vo, 4	00
Johnson's (L. J.) Statics by Algebraic and Graphic Methods.	8vo, 2	00
Laplace's Philosophical Essay on Probabilities. (Truscott and Emory.).	12mo, 2	00
Mahan's Treatise on Civil Engineering. (1873.) (Wood.).	8vo, 5	00
* Descriptive Geometry.	8vo, 1	50
Merriman's Elements of Precise Surveying and Geodesy.	8vo, 2	50
Merriman and Brooks's Handbook for Surveyors.	16mo, morocco, 2	00
Nugent's Plane Surveying.	8vo, 3	50
Ogden's Sewer Design.	12mo, 2	00
Parsons's Disposal of Municipal Refuse.	8vo, 2	00
Patton's Treatise on Civil Engineering.	8vo half leather, 7	50
Reed's Topographical Drawing and Sketching.	4to, 5	00
Rideal's Sewage and the Bacterial Purification of Sewage.	8vo, 4	00
Riemer's Shaft-sinking under Difficult Conditions. (Corning and Peele.).	8vo, 3	00
Siebert and Biggin's Modern Stone-cutting and Masonry.	8vo, 1	50
Smith's Manual of Topographical Drawing. (McMillan.).	8vo, 2	50
Sondericker's Graphic Statics, with Applications to Trusses, Beams, and Arches.	8vo, 2	00
Taylor and Thompson's Treatise on Concrete, Plain and Reinforced.	16mo, morocco, 5	00
Tracy's Plane Surveying.	16mo, morocco, 3	00
* Trautwine's Civil Engineer's Pocket-book.	16mo, morocco, 5	00
Venable's Garbage Crematories in America.	8vo, 2	00
Wait's Engineering and Architectural Jurisprudence.	8vo, 6	00
	Sheep,	6 50
Law of Operations Preliminary to Construction in Engineering and Architecture.	8vo, 5	00
	Sheep,	5 50
Law of Contracts.	8vo, 3	00
Warren's Stereotomy—Problems in Stone-cutting.	8vo, 2	50
Webb's Problems in the Use and Adjustment of Engineering Instruments.	16mo, morocco, 1	25
Wilson's Topographic Surveying.	8vo, 3	50

BRIDGES AND ROOFS.

Boller's Practical Treatise on the Construction of Iron Highway Bridges.	8vo, 2	00
Burr and Falk's Influence Lines for Bridge and Roof Computations.	8vo, 3	00
Design and Construction of Metallic Bridges	8vo, 5	00
Du Bois's Mechanics of Engineering. Vol II.	Small 4to, 10	00
Foster's Treatise on Wooden Trestle Bridges.	4to, 5	00
Fowler's Ordinary Foundations	8vo, 3	50
Greene's Roof Trusses.	8vo, 1	25
Bridge Trusses.	8vo, 2	50
Arches in Wood, Iron, and Stone.	8vo, 2	50
Grimm's Secondary Stresses in Bridge Trusses. (In Press.)		
Howe's Treatise on Arches.	8vo, 4	00
Design of Simple Roof-trusses in Wood and Steel.	8vo, 2	00
Symmetrical Masonry Arches.	8vo, 2	50
Johnson, Bryan, and Turneaure's Theory and Practice in the Designing of Modern Framed Structures.	Small 4to, 10	00
Merriman and Jacoby's Text-book on Roofs and Bridges:		
Part I. Stresses in Simple Trusses.	8vo, 2	50
Part II. Graphic Statics.	8vo, 2	50
Part III. Bridge Design.	8vo, 2	50
Part IV. Higher Structures.	8vo, 2	50

Morison's Memphis Bridge.	4to, 10	00
Waddell's De Pontibus, a Pocket-book for Bridge Engineers.	16mo, morocco,	2 00
* Specifications for Steel Bridges.	12mo,	50
Wright's Designing of Draw-spans. Two parts in one volume.	8vo, 3	50

HYDRAULICS.

Barnes's Ice Formation.	8vo,	3 00
Bazin's Experiments upon the Contraction of the Liquid Vein Issuing from an Orifice. (Trautwine.).	8vo,	2 00
Bovey's Treatise on Hydraulics.	8vo,	5 00
Church's Mechanics of Engineering.	8vo,	6 00
Diagrams of Mean Velocity of Water in Open Channels.	paper,	1 50
Hydraulic Motors.	8vo,	2 00
Coffin's Graphical Solution of Hydraulic Problems.	16mo, morocco,	2 50
Flather's Dynamometers, and the Measurement of Power.	12mo,	3 00
Folwell's Water-supply Engineering.	8vo,	4 00
Frizzell's Water-power.	8vo,	5 00
Fuertes's Water and Public Health.	12mo,	1 50
Water-filtration Works.	12mo,	2 50
Ganguillet and Kutter's General Formula for the Uniform Flow of Water in Rivers and Other Channels. (Hering and Trautwine.).	8vo,	4 00
Hazen's Clean Water and How to Get It.	Large 12mo,	1 50
Filtration of Public Water-supply.	8vo,	3 00
Hazlehurst's Towers and Tanks for Water-works.	8vo,	2 50
Herschel's 115 Experiments on the Carrying Capacity of Large, Riveted, Metal Conduits.	8vo,	2 00
* Hubbard and Kiersted's Water-works Management and Maintenance.	8vo,	4 00
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.)	8vo,	4 00
Merriman's Treatise on Hydraulics.	8vo,	5 00
* Michie's Elements of Analytical Mechanics.	8vo,	4 00
Schuylar's Reservoirs for Irrigation, Water-power, and Domestic Water-supply.	Large 8vo,	5 00
* Thomas and Watt's Improvement of Rivers.	4to,	6 00
Turneaure and Russell's Public Water-supplies.	8vo,	5 00
Wegmann's Design and Construction of Dams. 5th Edition, enlarged.	4to,	6 00
Water-supply of the City of New York from 1658 to 1895.	4to,	10 00
Whipple's Value of Pure Water.	Large 12mo,	1 00
Williams and Hazen's Hydraulic Tables.	8vo,	1 50
Wilson's Irrigation Engineering.	Small 8vo,	4 00
Wolff's Windmill as a Prime Mover.	8vo,	3 00
Wood's Turbines.	8vo,	2 50
Elements of Analytical Mechanics.	8vo,	3 00

MATERIALS OF ENGINEERING.

Baker's Treatise on Masonry Construction.	8vo,	5 00
Roads and Pavements.	8vo,	5 00
Black's United States Public Works.	Oblong 4to,	5 00
* Bovey's Strength of Materials and Theory of Structures.	8vo,	7 50
Burr's Elasticity and Resistance of the Materials of Engineering.	8vo,	7 50
Byrne's Highway Construction.	8vo,	5 00
Inspection of the Materials and Workmanship Employed in Construction.	16mo,	3 00
Church's Mechanics of Engineering.	8vo,	6 00
Du Bois's Mechanics of Engineering. Vol. I.	Small 4to	7 50
* Eckel's Cements, Limes, and Plasters.	8vo,	6 00

Johnson's Materials of Construction.....	Large 8vo, 6 00
Fowler's Ordinary Foundations.....	.8vo, 3 50
Graves's Forest Mensuration.....	.8vo, 4 00
* Greene's Structural Mechanics.....	.8vo, 2 50
Keep's Cast Iron.....	.8vo, 2 50
Lanza's Applied Mechanics.....	.8vo, 7 50
Martens's Handbook on Testing Materials. (Henning.) 2 vols.	.8vo, 7 50
Maurer's Technical Mechanics.....	.8vo, 4 00
Merrill's Stones for Building and Decoration.....	.8vo, 5 00
Merriman's Mechanics of Materials.....	.8vo, 5 00
* Strength of Materials.....	12mo, 1 00
Metcalf's Steel. A Manual for Steel-users.....	12mo, 2 00
Patton's Practical Treatise on Foundations.....	.8vo, 5 00
Richardson's Modern Asphalt Pavements.....	.8vo, 3 00
Richey's Handbook for Superintendents of Construction.....	16mo, mor., 4 00
* Ries's Clays: Their Occurrence, Properties, and Uses.....	.8vo, 5 00
Rockwell's Roads and Pavements in France.....	12mo, 1 25
Sabin's Industrial and Artistic Technology of Paints and Varnish.....	.8vo, 3 00
* Schwarz's Longleaf Pine in Virgin Forest.....	12mo, 1 25
Smith's Materials of Machines.....	12mo, 1 00
Snow's Principal Species of Wood.....	.8vo, 3 50
Spalding's Hydraulic Cement.....	12mo, 2 00
Text-book on Roads and Pavements.....	12mo, 2 00
Taylor and Thompson's Treatise on Concrete, Plain and Reinforced.....	.8vo, 5 00
Thurston's Materials of Engineering. 3 Parts.....	.8vo, 8 00
Part I. Non-metallic Materials of Engineering and Metallurgy.....	.8vo, 2 00
Part II. Iron and Steel.....	.8vo, 3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	.8vo, 2 50
Tillson's Street Pavements and Paving Materials.....	.8vo, 4 00
Turneaure and Maurer's Principles of Reinforced Concrete Construction.....	.8vo, 3 00
Waddell's De Pogibus. (A Pocket-book for Bridge Engineers.)	16mo, mor., 2 00
* Specifications for Steel Bridges.....	12mo, 50
Wood's (De V.) Treatise on the Resistance of Materials, and an Appendix on the Preservation of Timber.....	.8vo, 2 00
Wood's (De V.) Elements of Analytical Mechanics.....	.8vo, 3 00
Wood's (M. P.) Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	.8vo, 4 00

RAILWAY ENGINEERING.

Andrew's Handbook for Street Railway Engineers.....	3x5 inches, morocco, 1 25
Berg's Buildings and Structures of American Railroads.....	4to, 5 00
Brook's Handbook of Street Railroad Location.....	16mo, morocco, 1 50
Butt's Civil Engineer's Field-book.....	16mo, morocco, 2 50
Crandall's Transition Curve.....	16mo, morocco, 1 50
Railway and Other Earthwork Tables.....	.8vo, 1 50
Crockett's Methods for Earthwork Computations. (In Press)	
Dawson's "Engineering" and Electric Traction Pocket-book	16mo, morocco 5 00
Dredge's History of the Pennsylvania Railroad: (1879).....	Paper, 5 00
Fisher's Table of Cubic Yards.....	Cardboard, 25
Godwin's Railroad Engineers' Field-book and Explorers' Guide	16mo, mor., 2 50
Hudson's Tables for Calculating the Cubic Contents of Excavations and Embankments.....	.8vo, 1 00
Molitor and Beard's Manual for Resident Engineers.....	16mo, 1 00
Nagle's Field Manual for Railroad Engineers.....	16mo, morocco, 3 00
Philbrick's Field Manual for Engineers.....	16mo, morocco, 3 00
Raymond's Elements of Railroad Engineering. (In Press.)	

Searles's Field Engineering.	16mo, morocco,	3 00
Railroad Spiral.	16mo, morocco,	1 50
Taylor's Prismoidal Formulas and Earthwork.	8vo,	1 50
* Trautwine's Method of Calculating the Cube Contents of Excavations and Embankments by the Aid of Diagrams.	8vo,	2 00
The Field Practice of Laying Out Circular Curves for Railroads.	12mo, morocco,	2 50
Cross-section Sheet.	Paper,	.25
Webb's Railroad Construction.	16mo, morocco,	5 00
Economics of Railroad Construction.	Large 12mo,	2 50
Wellington's Economic Theory of the Location of Railways.	Small 8vo,	5 00

DRAWING.

Barr's Kinematics of Machinery.	8vo,	2 50
* Bartlett's Mechanical Drawing.	8vo,	3 00
* " " " Abridged Ed.	8vo,	1 50
Coolidge's Manual of Drawing.	8vo, paper,	1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical Engineers.	Oblong 4to,	2 50
Durley's Kinematics of Machines.	8vo,	4 00
Emch's Introduction to Projective Geometry and its Applications.	8vo,	2 50
Hill's Text-book on Shades and Shadows, and Perspective.	8vo,	2 00
Jamison's Elements of Mechanical Drawing.	8vo,	2 50
Advanced Mechanical Drawing.	8vo,	2 00
Jones's Machine Design:		
Part I. Kinematics of Machinery.	8vo,	1 50
Part II. Form, Strength, and Proportions of Parts.	8vo,	3 00
MacCord's Elements of Descriptive Geometry.	8vo,	3 00
Kinematics; or, Practical Mechanism.	8vo,	5 00
Mechanical Drawing.	4to,	4 00
Velocity Diagrams.	8vo,	1 50
MacLeod's Descriptive Geometry.	Small 8vo,	1 50
* Mahan's Descriptive Geometry and Stone-cutting.	8vo,	1 50
Industrial Drawing. (Thompson.).	8vo,	3 50
Moyer's Descriptive Geometry.	8vo,	2 00
Reed's Topographical Drawing and Sketching.	4to,	5 00
Reid's Course in Mechanical Drawing.	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.	8vo,	3 00
Robinson's Principles of Mechanism.	8vo,	3 00
Schwamb and Merrill's Elements of Mechanism.	8vo,	3 00
Smith's (R. S.) Manual of Topographical Drawing. (McMillan.).	8vo,	2 50
Smith (A. W.) and Marx's Machine Design.	8vo,	3 00
* Titcomb's Elements of Mechanical Drawing.	Oblong 8vo,	1 25
Warren's Elements of Plane and Solid Free-hand Geometrical Drawing.	12mo,	1 00
Drafting Instruments and Operations.	12mo,	1 25
Manual of Elementary Projection Drawing.	12mo,	1 50
Manual of Elementary Problems in the Linear Perspective of Form and Shadow.	12mo,	1 00
Plane Problems in Elementary Geometry.	12mo,	1 25
Elements of Descriptive Geometry, Shadows, and Perspective.	8vo,	3 50
General Problems of Shades and Shadows.	8vo,	3 00
Elements of Machine Construction and Drawing.	8vo,	7 50
Problems, Theorems, and Examples in Descriptive Geometry.	8vo,	2 50
Weisbach's Kinematics and Power of Transmission. (Hermann and Klein.).	8vo,	5 00
Whelpley's Practical Instruction in the Art of Letter Engraving.	12mo,	2 00
Wilson's (H. M.) Topographic Surveying.	8vo,	3 50

Wilson's (V. T.) Free-hand Perspective.	8vo,	2 50
Wilson's (V. T.) Free-hand Lettering.	8vo,	1 00
Woolf's Elementary Course in Descriptive Geometry.	Large 8vo,	3 00

ELECTRICITY AND PHYSICS.

* Abegg's Theory of Electrolytic Dissociation. (Von Ende.)	12mo,	1 25
Anthony and Brackett's Text-book of Physics. (Magic.).	Small 8vo,	3 00
Anthony's Lecture-notes on the Theory of Electrical Measurements.	12mo,	1 00
Benjamin's History of Electricity.	8vo,	3 00
Voltaic Cell.	8vo,	3 00
Betts's Lead Refining and Electrolysis. (In Press.)		
Classen's Quantitative Chemical Analysis by Electrolysis. (Boltwood.).	8vo,	3 00
* Collins's Manual of Wireless Telegraphy.	12mo,	1 50
Crehore and Squier's Polarizing Photo-chronograph.	8vo,	3 00
* Danneel's Electrochemistry. (Merriam.).	12mo,	1 25
Dawson's "Engineering" and Electric Traction Pocket-book.	16mo, morocco,	5 00
Dolezalek's Theory of the Lead Accumulator (Storage Battery). (Von Ende.)		
Duhem's Thermodynamics and Chemistry. (Burgess.).	12mo,	2 50
Flather's Dynamometers, and the Measurement of Power.	8vo,	4 00
Gilbert's De Magnete. (Mottelay.).	12mo,	3 00
Hanchett's Alternating Currents Explained.	12mo,	1 00
Hering's Ready Reference Tables (Conversion Factors).	16mo, morocco,	2 50
Hobart and Ellis's High-speed Dynamo Electric Machinery. (In Press.)		
Holman's Precision of Measurements.	8vo,	2 00
Telescopic Mirror-scale Method, Adjustments, and Tests.	Large 8vo,	75
Karapetoff's Experimental Electrical Engineering. (In Press.)		
Kinzbrunner's Testing of Continuous-current Machines.	8vo,	2 00
Landauer's Spectrum Analysis. (Tingle.).	8vo,	3 00
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.).	12mo,	3 00
Löb's Electrochemistry of Organic Compounds. (Lorenz.).	8vo,	3 00
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I. and II.	8vo, each,	6 00
* Michie's Elements of Wave Motion Relating to Sound and Light.	8vo,	4 00
Niaudet's Elementary Treatise on Electric Batteries. (Fishback.).	12mo,	2 50
Norris's Introduction to the Study of Electrical Engineering. (In Press.)		
* Parshall and Hobart's Electric Machine Design.	4to, half morocco,	12 50
Reagan's Locomotives: Simple, Compound, and Electric. New Edition.		
	Large 12mo,	3 50
* Rosenberg's Electrical Engineering. (Haldane Gee—Kinzbrunner.).	8vo,	2 00
Ryan, Norris, and Hoxie's Electrical Machinery. Vol. I.	8vo,	2 50
Thurston's Stationary Steam-engines.	8vo,	2 50
* Tillman's Elementary Lessons in Heat.	8vo,	1 50
Tory and Pitcher's Manual of Laboratory Physics.	Small 8vo,	2 00
Ulke's Modern Electrolytic Copper Refining.	8vo,	3 00

LAW.

* Davis's Elements of Law.	8vo,	2 50
* Treatise on the Military Law of United States.	8vo,	7 00
*	Sheep,	7 50
* Dudley's Military Law and the Procedure of Courts-martial.	Large 12mo,	2 50
Manual for Courts-martial.	16mo, morocco,	1 50
Wait's Engineering and Architectural Jurisprudence.	8vo,	6 00
	Sheep,	6 50
Law of Operations Preliminary to Construction in Engineering and Architecture.	8vo	5 00
	Sheep,	5 50
Law of Contracts.	8vo,	3 00
Winthrop's Abridgment of Military Law.	12mo,	2 50

MANUFACTURES.

Bernadou's Smokeless Powder—Nitro-cellulose and Theory of the Cellulose Molecule.....	12mo,	2 50
Bolland's Iron Founder.....	12mo,	2 50
The Iron Founder," Supplement.....	12mo,	2 50
Encyclopedia of Founding and Dictionary of Foundry Terms Used in the Practice of Moulding.....	12mo,	3 00
* Claassen's Beet-sugar Manufacture. (Hall and Rolfe.).....	8vo,	3 00
* Eckel's Cements, Limes, and Plasters.....	8vo,	6 00
Eissler's Modern High Explosives.....	8vo,	4 00
Effront's Enzymes and their Applications. (Prescott.).....	8vo,	3 00
Fitzgerald's Boston Machinist.....	12mo,	1 00
Ford's Boiler Making for Boiler Makers.....	18mo,	1 00
Herrick's Denatured or Industrial Alcohol.....	8vo,	4 00
Holley and Ladd's Analysis of Mixed Paints, Color Pigments, and Varnishes. (In Press.)		
Hopkins's Oil-chemists' Handbook.....	8vo,	3 00
Keep's Cast Iron.....	8vo,	2 50
Leach's The Inspection and Analysis of Food with Special Reference to State Control.....	Large 8vo,	7 50
* McKay and Larsen's Principles and Practice of Butter-making.....	8vo,	1 50
Maire's Modern Pigments and their Vehicles. (In Press.)		
Matthews's The Textile Fibres. 2d Edition, Rewritten.....	8vo,	4 00
Metcalf's Steel. A Manual for Steel-users.....	12mo,	2 00
Metcalf's Cost of Manufactures—And the Administration of Workshops.....	8vo,	5 00
Meyer's Modern Locomotive Construction.....	4to,	10 00
Morse's Calculations used in Cane-sugar Factories.....	16mo, morocco,	1 50
* Reisig's Guide to Piece-dyeing.....	8vo,	25 00
Rice's Concrete-block Manufacture.....	8vo,	2 00
Sabin's Industrial and Artistic Technology of Paints and Varnish.....	8vo,	3 00
Smith's Press-working of Metals.....	8vo,	3 00
Spalding's Hydraulic Cement.....	12mo,	2 00
Spencer's Handbook for Chemists of Beet-sugar Houses.....	16mo, morocco,	3 00
Handbook for Cane Sugar Manufacturers.....	16mo, morocco,	3 00
Taylor and Thompson's Treatise on Concrete, Plain and Reinforced.....	8vo,	5 00
Thurston's Manual of Steam-boilers, their Designs, Construction and Operation.....	8vo,	5 00
Ware's Beet-sugar Manufacture and Refining. Vol. I.....	Small 8vo,	4 00
" " " " " Vol. II.....	8vo,	5 00
Weaver's Military Explosives.....	8vo,	3 00
West's American Foundry Practice.....	12mo,	2 50
Moulder's Text-book.....	12mo,	2 50
Wolf's Windmill as a Prime Mover.....	8vo,	3 00
Wood's Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	8vo,	4 00

MATHEMATICS.

Baker's Elliptic Functions.....	8vo,	1 50
Briggs's Elements of Plane Analytic Geometry.....	12mo,	1 00
Buchanan's Plane and Spherical Trigonometry. (In Press.)		
Compton's Manual of Logarithmic Computations.....	12mo,	1 50
Davis's Introduction to the Logic of Algebra.....	8vo,	1 50
* Dickson's College Algebra.....	Large 12mo,	1 50
* Introduction to the Theory of Algebraic Equations.....	Large 12mo,	1 25
Emch's Introduction to Projective Geometry and its Applications.....	8vo,	2 50
Halsted's Elements of Geometry.....	8vo,	1 75
Elementary Synthetic Geometry.....	8vo,	1 50
* Rational Geometry.....	12mo,	1 50

* Johnson's (J. B.) Three-place Logarithmic Tables: Vest-pocket size, paper,	15
100 copies for	5 00
Mounted on heavy cardboard, 8 x 10 inches,	25
10 copies for	2 00
Johnson's (W. W.) Elementary Treatise on Differential Calculus. Small 8vo,	3 00
Elementary Treatise on the Integral Calculus	Small 8vo, 1 50
Johnson's (W. W.) Curve Tracing in Cartesian Co-ordinates	12mo, 1 00
Johnson's (W. W.) Treatise on Ordinary and Partial Differential Equations.	
Small 8vo, 3 50	
Johnson's Treatise on the Integral Calculus	Small 8vo, 3 00
Johnson's (W. W.) Theory of Errors and the Method of Least Squares	12mo, 1 50
* Johnson's (W. W.) Theoretical Mechanics	12mo, 3 00
Laplace's Philosophical Essay on Probabilities. (Truscott and Emory.)	12mo, 2 00
* Ludlow and Bass. Elements of Trigonometry and Logarithmic and Other	
Tables	8vo, 3 00
Trigonometry and Tables published separately	Each, 2 00
* Ludlow's Logarithmic and Trigonometric Tables	8vo, 1 00
Manning's Irrational Numbers and their Representation by Sequences and Series	
12mo, 1 25	
Mathematical Monographs. Edited by Mansfield Merriman and Robert	
S. Woodward.	Octavo, each 1 00
No. 1. History of Modern Mathematics, by David Eugene Smith.	
No. 2. Synthetic Projective Geometry, by George Bruce Halsted.	
No. 3. Determinants, by Laenas Gifford Weld. No. 4. Hyper-	
bolic Functions, by James McMahon. No. 5. Harmonic Func-	
tions, by William E. Byerly. No. 6. Grassmann's Space Analysis,	
by Edward W. Hyde. No. 7. Probability and Theory of Errors,	
by Robert S. Woodward. No. 8. Vector Analysis and Quaternions,	
by Alexander Macfarlane. No. 9. Differential Equations, by	
William Woolsey Johnson. No. 10. The Solution of Equations,	
by Mansfield Merriman. No. 11. Functions of a Complex Variable,	
by Thomas S. Fiske.	
Maurer's Technical Mechanics.	8vo, 4 00
Merriman's Method of Least Squares.	8vo, 2 00
Rice and Johnson's Elementary Treatise on the Differential Calculus. Sm. 8vo, 3 00	
Differential and Integral Calculus. 2 vols. in one.	Small 8vo, 3 50
* Veblen and Lennes's Introduction to the Real Infinitesimal Analysis of One	
Variable	8vo, 2 00
Wood's Elements of Co-ordinate Geometry.	8vo, 2 00
Trigonometry: Analytical, Plane, and Spherical	12mo, 1 00

MECHANICAL ENGINEERING.

MATERIALS OF ENGINEERING, STEAM-ENGINES AND BOILERS.

Bacon's Forge Practice.	12mo, 1 50
Baldwin's Steam Heating for Buildings.	12mo, 2 50
Barr's Kinematics of Machinery.	8vo, 2 50
* Bartlett's Mechanical Drawing.	8vo, 3 00
* " " " Abridged Ed.	8vo, 1 50
Benjamin's Wrinkles and Recipes.	12mo, 2 00
Carpenter's Experimental Engineering.	8vo, 6 00
Heating and Ventilating Buildings.	8vo, 4 00
Clerk's Gas and Oil Engine.	Small 8vo, 4 00
Coolidge's Manual of Drawing.	8vo, paper, 1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical En-	
gineers.	Oblong 4to, 2 50
Cromwell's Treatise on Toothed Gearing.	12mo, 1 50
Treatise on Belts and Pulleys.	12mo, 1 50

Durley's Kinematics of Machines.	8vo,	4 00
Flather's Dynamometers and the Measurement of Power.	12mo,	3 00
Rope Driving.	12mo,	2 00
Gill's Gas and Fuel Analysis for Engineers.	12mo,	1 25
Hall's Car Lubrication.	12mo,	1 00
Hering's Ready Reference Tables (Conversion Factors).	16mo, morocco,	2 50
Hutton's The Gas Engine.	8vo,	5 00
Jamison's Mechanical Drawing.	8vo,	2 50
Jones's Machine Design:		
Part I. Kinematics of Machinery.	8vo,	1 50
Part II. Form, Strength, and Proportions of Parts.	8vo,	3 00
Kent's Mechanical Engineers' Pocket-book.	16mo, morocco,	5 00
Kerr's Power and Power Transmission.	8vo,	2 00
Leonard's Machine Shop, Tools, and Methods.	8vo,	4 00
* Lorenz's Modern Refrigerating Machinery. (Pope, Haven, and Dean.)	8vo,	4 00
MacCord's Kinematics; or, Practical Mechanism.	8vo,	5 00
Mechanical Drawing.	4to,	4 00
Velocity Diagrams.	8vo,	1 50
MacFarland's Standard Reduction Factors for Gases.	8vo,	1 50
Mahan's Industrial Drawing. (Thompson.)	8vo,	3 50
Poole's Calorific Power of Fuels.	8vo,	3 00
Reid's Course in Mechanical Drawing.	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.	8vo,	3 00
Richard's Compressed Air.	12mo,	1 50
Robinson's Principles of Mechanism.	8vo,	3 00
Schwamb and Merrill's Elements of Mechanism.	8vo,	3 00
Smith's (O.) Press-working of Metals.	8vo,	3 00
Smith (A. W.) and Marx's Machine Design.	8vo,	3 00
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work.	8vo,	3 00
Animal as a Machine and Prime Motor, and the Laws of Energetics.	12mo,	1 00
Tillson's Complete Automobile Instructor.	16mo,	1 50
	Morocco,	2 00
Warren's Elements of Machine Construction and Drawing.	8vo,	7 50
Weisbach's Kinematics and the Power of Transmission. (Herrmann—Klein.).	8vo,	5 00
Machinery of Transmission and Governors. (Herrmann—Klein.).	8vo,	5 00
Wolff's Windmill as a Prime Mover.	8vo,	3 00
Wood's Turbines.	8vo,	2 50

MATERIALS OF ENGINEERING.

* Bovey's Strength of Materials and Theory of Structures.	8vo,	7 50
Burr's Elasticity and Resistance of the Materials of Engineering. 6th Edition.		
Reset.	8vo,	7 50
Church's Mechanics of Engineering.	8vo,	6 00
* Greene's Structural Mechanics.	8vo,	2 50
Johnson's Materials of Construction.	8vo,	6 00
Keep's Cast Iron.	8vo,	2 50
Lanza's Applied Mechanics.	8vo,	7 50
Martens's Handbook on Testing Materials. (Henning.)	8vo,	7 50
Maurer's Technical Mechanics.	8vo,	4 00
Merriman's Mechanics of Materials.	8vo,	5 00
* Strength of Materials.	12mo,	1 00
Metcalf's Steel. A Manual for Steel-users.	12mo,	2 00
Sabin's Industrial and Artistic Technology of Paints and Varnish.	8vo,	3 00
Smith's Materials of Machines.	12mo,	1 00
Thurston's Materials of Engineering.	3 vols., 8vo,	8 00
Part II. Iron and Steel.	8vo,	3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.	8vo,	3 50

Wood's (De V.) Treatise on the Resistance of Materials and an Appendix on the Preservation of Timber.....	8vo, 2 00
Elements of Analytical Mechanics.....	8vo, 3 00
Wood's (M. P.) Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	8vo, 4 00

STEAM-ENGINES AND BOILERS.

Berry's Temperature-entropy Diagram.....	12mo, 1 25
Carnot's Reflections on the Motive Power of Heat. (Thurston).	12mo, 1 50
Creighton's Steam-engine and other Heat-motors.....	8vo, 5 00
Dawson's "Engineering" and Electric Traction Pocket-book....	16mo, mor., 5 00
Ford's Boiler Making for Boiler Makers.....	18mo, 1 00
Goss's Locomotive Sparks.....	8vo, 2 00
Locomotive Performance	8vo, 5 00
Hemenway's Indicator Practice and Steam-engine Economy.....	12mo, 2 00
Hutton's Mechanical Engineering of Power Plants.....	8vo, 5 00
Heat and Heat-engines.....	8vo, 5 00
Kent's Steam boiler Economy.....	8vo, 4 00
Kneass's Practice and Theory of the Injector.....	8vo, 1 50
MacCord's Slide-valves.....	8vo, 2 00
Meyer's Modern Locomotive Construction.....	4to, 10 00
Peabody's Manual of the Steam-engine Indicator.....	12mo, 1 50
Tables of the Properties of Saturated Steam and Other Vapors.....	8vo, 1 00
Thermodynamics of the Steam-engine and Other Heat-engines.....	8vo, 5 00
Valve-gears for Steam-engines.....	8vo, 2 50
Peabody and Miller's Steam-boilers.....	8vo, 4 00
Pray's Twenty Years with the Indicator.....	Large 8vo, 2 50
Pupin's Thermodynamics of Reversible Cycles in Gases and Saturated Vapors. (Osterberg).	12mo, 1 25
Reagan's Locomotives: Simple, Compound, and Electric. New Edition.	Large 12mo, 3 50
Sinclair's Locomotive Engine Running and Management.....	12mo, 2 00
Smart's Handbook of Engineering Laboratory Practice.....	12mo, 2 50
Snow's Steam-boiler Practice.....	8vo, 3 00
Spangler's Valve-gears.....	8vo, 2 50
Notes on Thermodynamics.....	12mo, 1 00
Spangler, Greene, and Marshall's Elements of Steam-engineering.....	8vo, 3 00
Thomas's Steam-turbines.....	8vo, 3 50
Thurston's Handy Tables.....	8vo, 1 50
Manual of the Steam-engine.....	2 vols., 8vo, 10 00
Part I. History, Structure, and Theory.....	8vo, 6 00
Part II. Design, Construction, and Operation.....	8vo, 6 00
Handbook of Engine and Boiler Trials, and the Use of the Indicator and the Prony Brake.....	8vo, 5 00
Stationary Steam-engines.....	8vo, 2 50
Steam-boiler Explosions in Theory and in Practice	12mo, 1 50
Manual of Steam-boilers, their Designs, Construction, and Operation	8vo, 5 00
Wehrenfennig's Analysis and Softening of Boiler Feed-water (Patterson)	8vo, 4 00
Weisbach's Heat, Steam, and Steam-engines. (Du Bois).	8vo, 5 00
Whitham's Steam-engine Design.....	8vo, 5 00
Wood's Thermodynamics, Heat Motors, and Refrigerating Machines.....	8vo, 4 00

MECHANICS AND MACHINERY.

Barr's Kinematics of Machinery.....	8vo, 2 50
* Bovey's Strength of Materials and Theory of Structures	8vo, 7 50
Chase's The Art of Pattern-making.....	12mo, 2 50

Spangler, Greene, and Marshall's Elements of Steam-engineering.....	8vo, 3 00
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work.....	8vo, 3 00
Animal as a Machine and Prime Motor, and the Laws of Energetics. 12mo, 1 00	
Tillson's Complete Automobile Instructor.....	16mo, 1 50
	Morocco, 2 00
Warren's Elements of Machine Construction and Drawing.....	8vo, 7 50
Weisbach's Kinematics and Power of Transmission. (Herrmann—Klein.) 8vo.	5 00
Machinery of Transmission and Governors. (Herrmann—Klein.) 8vo.	5 00
Wood's Elements of Analytical Mechanics.....	8vo, 3 00
Principles of Elementary Mechanics.....	12mo, 1 25
Turbines.....	8vo, 2 50
The World's Columbian Exposition of 189340, 1 00

MEDICAL.

* Bolduan's Immune Sera	12mo, 1 50
De Fursac's Manual of Psychiatry. (Rosanoff and Collins.) Large 12mo, 2 50	
Ehrlich's Collected Studies on Immunity. (Bolduan.)	8vo, 6 00
* Fischer's Physiology of Alimentation..... Large 12mo, cloth, 2 00	
Hammarsten's Text-book on Physiological Chemistry. (Mandel.)..... 8vo, 4 00	
Lassar-Cohn's Practical Urinary Analysis. (Lorenz.)..... 12mo, 1 00	
* Pauli's Physical Chemistry in the Service of Medicine. (Fischer.) .. 12mo, 1 25	
* Pozzi-Escot's The Toxins and Venoms and their Antibodies. (Cohn.) .12mo, 1 00	
Rostoski's Serum Diagnosis. (Bolduan.)	12mo, 1 00
Salkowski's Physiological and Pathological Chemistry. (Orndorff.) .. 8vo, 2 50	
* Satterlee's Outlines of Human Embryology	12mo, 1 25
Steel's Treatise on the Diseases of the Dog..... 8vo, 3 50	
Von Behring's Suppression of Tuberculosis. (Bolduan.)	12mo, 1 00
Woodhull's Notes on Military Hygiene	16mo, 1 50
* Personal Hygiene.....	12mo, 1 00
Wylling's An Elementary Course in Inorganic Pharmaceutical and Medical Chemistry	12mo, 2 00

METALLURGY.

Betts's Lead Refining by Electrolysis. (In Press.)
Egleston's Metallurgy of Silver, Gold, and Mercury:

Vol. I. Silver	8vo, 7 50
Vol. II. Gold and Mercury.....	8vo, 7 50
Goesel's Minerals and Metals: A Reference Book.....	16mo, mor. 3 00
* Iles's Lead-smelting	12mo, 2 50
Keep's Cast Iron.....	8vo, 2 50
Kunhardt's Practice of Ore Dressing in Europe.....	8vo, 1 50
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.) 12mo, 3 00	
Metcalfe's Steel. A Manual for Steel-users.....	12mo, 2 00
Miller's Cyanide Process.....	12mo, 1 00
Minet's Production of Aluminum and its Industrial Use. (Waldo.)... 12mo, 2 50	
Robine and Lenglen's Cyanide Industry. (Le Clerc.)	8vo, 4 00
Smith's Materials of Machines.....	12mo, 1 00
Thurston's Materials of Engineering. In Three Parts.....	8vo, 8 00
Part II. Iron and Steel.....	8vo, 3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	8vo, 2 50
Ulke's Modern Electrolytic Copper Refining.....	8vo, 3 00

MINERALOGY.

Barringer's Description of Minerals of Commercial Value. Oblong, morocco,	2 50
Boyd's Resources of Southwest Virginia.....	8vo, 3 00

Boyd's Map of Southwest Virginia.....	Pocket-book form.	2 00
* Browning's Introduction to the Rarer Elements.....	8vo,	1 50
Brush's Manual of Determinative Mineralogy. (Penfield).	8vo,	4 00
Chester's Catalogue of Minerals.....	8vo, paper,	1 00
	Cloth,	1 25
Dictionary of the Names of Minerals.....	8vo,	3 50
Dana's System of Mineralogy.....	Large 8vo, half leather,	12 50
First Appendix to Dana's New "System of Mineralogy.".....	Large 8vo,	1 00
Text-book of Mineralogy.....	8vo,	4 00
Minerals and How to Study Them	12mo,	1 50
Catalogue of American Localities of Minerals.....	Large 8vo,	1 00
Manual of Mineralogy and Petrography.....	12mo	2 00
Douglas's Untechnical Addresses on Technical Subjects.....	12mo,	1 00
Eakle's Mineral Tables.....	8vo,	1 25
Egleston's Catalogue of Minerals and Synonyms.....	8vo,	2 50
Goessel's Minerals and Metals: A Reference Book.....	16mo, mor.	3 00
Groth's Introduction to Chemical Crystallography (Marshall).....	12mo,	1 25
Iddings's Rock Minerals.....	8vo,	5 00
Johannsen's Key for the Determination of Rock-forming Minerals in Thin Sections. (In Press.)		
* Martin's Laboratory Guide to Qualitative Analysis with the Blowpipe.....	12mo,	60
Merrill's Non-metallic Minerals. Their Occurrence and Uses.....	8vo,	4 00
Stones for Building and Decoration	8vo,	5 00
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests.	8vo, paper,	50
Tables of Minerals.....	8vo,	1 00
* Richards's Synopsis of Mineral Characters.....	12mo, morocco,	1 25
* Ries's Clays. Their Occurrence, Properties, and Uses.....	8vo,	5 00
Rosenbusch's Microscopical Physiography of the Rock-making Minerals. (Iddings.).	8vo,	5 00
* Tillman's Text-book of Important Minerals and Rocks.....	8vo,	2 00

MINING.

Beard's Mine Gases and Explosions. (In Press.)		
Boyd's Resources of Southwest Virginia.....	8vo,	3 00
Map of Southwest Virginia.....	Pocket-book form,	2 00
Douglas's Untechnical Addresses on Technical Subjects.....	12mo,	1 00
Eissler's Modern High Explosives.....	8vo,	4 00
Goessel's Minerals and Metals: A Reference Book.....	16mo, mor.	3 00
Goodyear's Coal-mines of the Western Coast of the United States.....	12mo,	2 50
Ihseng's Manual of Mining.....	8vo,	5 00
* Iles's Lead-smelting.....	12mo,	2 50
Kunhardt's Practice of Ore Dressing in Europe.....	8vo,	1 50
Miller's Cyanide Process.....	12mo,	1 00
O'Driscoll's Notes on the Treatment of Gold Ores.....	8vo,	2 00
Robine and Lenglen's Cyanide Industry. (Le Clerc.).	8vo,	4 00
Weaver's Military Explosives.....	8vo,	3 00
Wilson's Cyanide Processes.....	12mo,	1 50
Chlorination Process.....	12mo,	1 50
Hydraulic and Placer Mining. 2d edition, rewritten	12mo,	2 50
Treatise on Practical and Theoretical Mine Ventilation.....	12mo,	1 25

SANITARY SCIENCE.

Bashore's Sanitation of a Country House.....	12mo,	1 00
* Outlines of Practical Sanitation.....	12mo,	1 25
Folwell's Sewerage. (Designing, Construction, and Maintenance.).	8vo,	3 00
Water-supply Engineering.....	8vo,	4 00

Fowler's Sewage Works Analyses.....	12mo,	2 00
Fuertes's Water and Public Health.....	12mo,	1 50
Water-filtration Works.....	12mo,	2 50
Gerhard's Guide to Sanitary House-inspection.....	16mo,	1 00
Sanitation of Public Buildings.....	12mo,	1 50
Hazen's Filtration of Public Water-supplies.....	8vo,	3 00
Leach's The Inspection and Analysis of Food with Special Reference to State Control.....	8vo,	7 50
Mason's Water-supply. (Considered principally from a Sanitary Standpoint).....	8vo,	4 00
Examination of Water. (Chemical and Bacteriological).....	12mo,	1 25
* Merriman's Elements of Sanitary Engineering.....	8vo,	2 00
Ogden's Sewer Design.....	12mo,	2 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Reference to Sanitary Water Analysis.....	12mo,	1 25
* Price's Handbook on Sanitation.....	12mo,	1 50
Richards's Cost of Food. A Study in Dietaries.....	12mo,	1 00
Cost of Living as Modified by Sanitary Science.....	12mo,	1 00
Cost of Shelter.....	12mo,	1 00
Richards and Woodman's Air. Water, and Food from a Sanitary Stand-point.....	8vo,	2 00
* Richards and Williams's The Dietary Computer.....	8vo,	1 50
Rideal's Sanitary and Bacterial Purification of Sewage.....	8vo,	4 00
Disinfection and the Preservation of Food.....	8vo,	4 00
Turneaure and Russell's Public Water-supplies.....	8vo,	5 00
Von Behring's Suppression of Tuberculosis. (Bolduan).....	12mo,	1 00
Whipple's Microscopy of Drinking-water.....	8vo,	3 50
Wilson's Air Conditioning. (In Press.)		
Winton's Microscopy of Vegetable Foods.....	8vo,	7 50
Woodhull's Notes on Military Hygiene.....	16mo,	1 50
* Personal Hygiene.....	12mo,	1 00

MISCELLANEOUS.

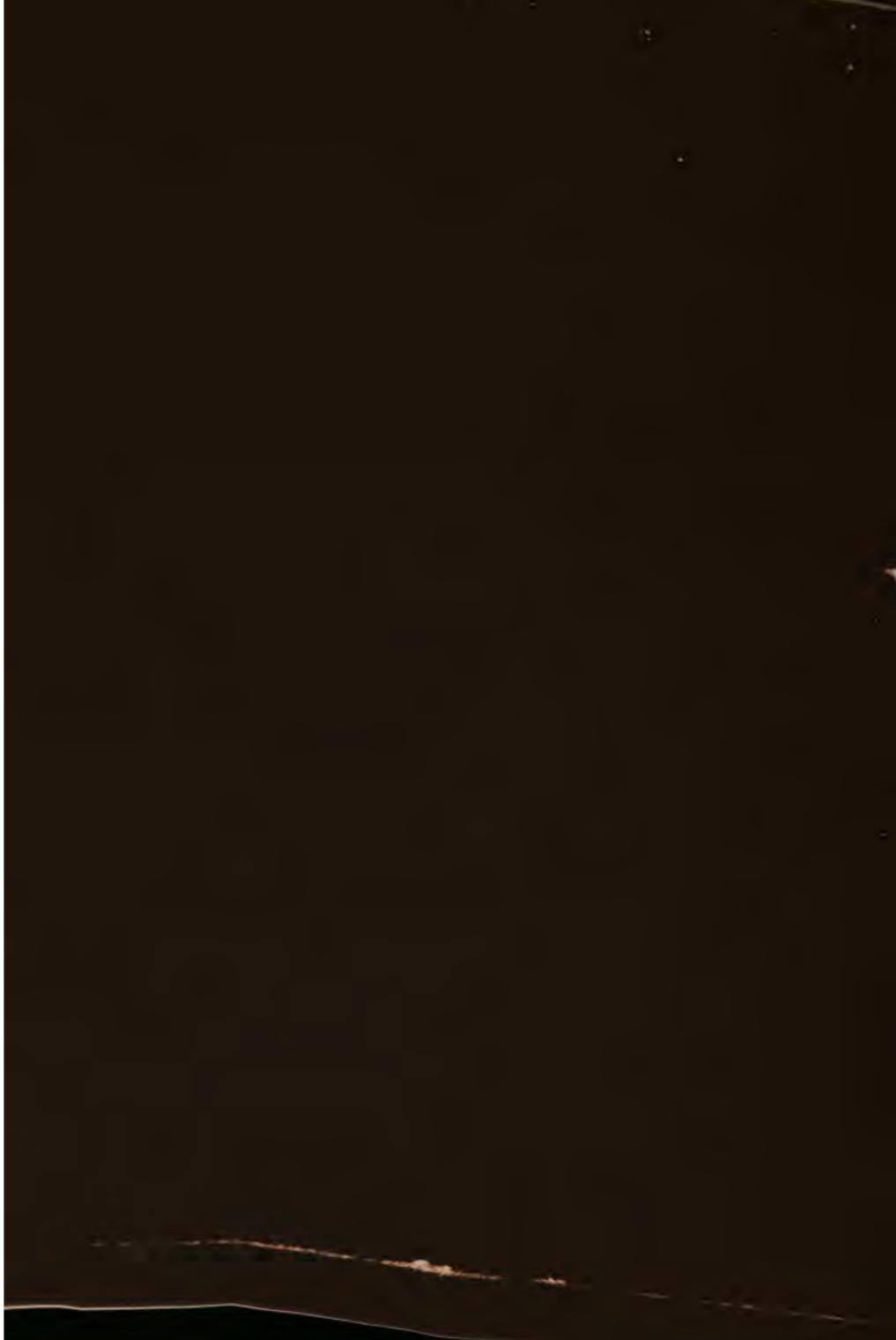
Association of State and National Food and Dairy Departments (Interstate Pure Food Commission):		
Tenth Annual Convention Held at Hartford, July 17-20, 1906....	8vo,	3 00
Eleventh Annual Convention, Held at Jamestown Tri-Centennial Exposition, July 16-19, 1907. (In Press.)		
Emmons's Geological Guide-book of the Rocky Mountain Excursion of the International Congress of Geologists.....	Large 8vo,	1 50
Ferrel's Popular Treatise on the Winds.....	8vo,	4 00
Gannett's Statistical Abstract of the World.....	24mo,	75
Gerhard's The Modern Bath and Bath-houses. (In Press.)		
Haines's American Railway Management.....	12mo,	2 50
Ricketts's History of Rensselaer Polytechnic Institute, 1824-1894. Small 8vo,	3 00	
Rotherham's Emphasized New Testament.....	Large 8vo,	2 00
Standage's Decorative Treatment of Wood, Glass, Metal, etc. (In Press.)		
The World's Columbian Exposition of 1893.....	4to,	1 00
Winslow's Elements of Applied Microscopy.....	12mo,	1 50

HEBREW AND CHALDEE TEXT-BOOKS.

Green's Elementary Hebrew Grammar.....	12mo,	1 25
Hebrew Chrestomathy.....	8vo,	2 00
Gesenius's Hebrew and Chaldee Lexicon to the Old Testament Scriptures. (Tregelles).....	Small 4to, half morocco,	5 00
Letteris's Hebrew Bible.....	8vo,	2 25







TP936 .M22
Modern pigments and their vehicles;
Kummel Library
AHH6296



3 2044 032 832 438

CABOT SCIENCE LIBRARY

CABOT CANCELLED

JUL 13 2006

BOOK DUE

FEB

FE

CH

FE

JUL

BO

G

CH

CH

CH

CH

CH

CH

CH

CH

GAYLORD

PRINTED IN U.S.A.

